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DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY
WILLIAM MCINNES, DIRECTING GEOLOGIST.

Summary Report, 1918, Part B

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OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1919
No. 1747

SUMMARY REPORT, 1918, PART B.

THE BRITISH COLUMBIA OFFICE.

Following a plan inaugurated by the Geological Survey about two years ago, when an office was established in the province of Alberta in order to keep in touch with drilling operations throughout the year, an office was opened in June 1918 in the city of Vancouver, British Columbia. A similar plan has long been in operation in the United States, where branches of the Geological Survey are located at different centres throughout the west and where experience has shown that good results have followed and that the effectiveness of the Survey's work has been greatly increased.

The objects of this British Columbia office are, to keep more closely and constantly in touch with prospecting and mining development throughout the province and in Yukon Territory, to work more closely in co-operation with the Provincial Department of Mines, and to act as a local distribution office for reports, maps, and other geological information.

The office is situated in rooms 509-512 Pacific building, on the corner of Howe and Hastings streets, in the city of Vancouver. The office is in charge of Charles Camsell, who has been assisted during the winter by Victor Dolmage.

The office is equipped with a good library containing as complete sets as possible of all the reports and maps issued by the Geological Survey, the Mines Branch, and the various provincial bureaus of mines. There is also a set of reports of the United States Geological Survey covering the western part of that country, also reports of some of the state geological surveys. Most of the important mining and geological periodicals are also received and there is a representative collection of standard books of reference on geology, petrography, ore deposits, and chemistry.

That there was ample need for this office and that the establishment is thoroughly appreciated by prospectors, mining engineers, and others engaged in the mining industry throughout British Columbia has already been shown by the use it has been put to by these men and the advantage taken of the facilities offered. The number of visitors to the office continues to increase and requests by mail and in person are frequently made for such rock and mineral determinations as it is possible to make without chemical equipment.

MAYO AREA, YUKON.

By W. E. Cockfield.

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INTRODUCTION.

The greater part of the field season of 1918 was spent in an examination of the mineral resources of Mayo area, upper Stewart River district. During the course of this work particular attention was paid to the deposits of tungsten on Dublin gulch and the silver-lead deposits on Lookout mountain (Mt. Haldane). Towards the close of the summer a visit was made to the silver-lead deposits on Spotted Fawn gulch, a

tributary to Little Twelvemile creek. When on the way out, learning through Mr. Wm. Sime of the Territorial Assay Office, of certain platinum deposits on Burwash creek it was decided to visit these, as the situation with regard to this mineral had become acute, owing to the supply from the Ural mountains in Russia being cut off. The information gained as the result of this visit has been furnished to J. J. O'Neill and is contained in his report dealing with the platinum situation in Canada.

The following report is intended to embody only the results obtained in the field, and must be considered as preliminary. Discussions as to the genesis of certain ore-bodies have been purposely omitted for the sake of brevity.

Mayo area for the past few years has been attracting more and more attention from a mining standpoint, as it is the only district in central Yukon, in which promising lode deposits have been located in considerable numbers. Consequently the writer received instructions to visit this district and examine the various deposits. No attempt was made to map the areal geology, as a reconnaissance map by Keele[1] has been published on which the general geology is shown.

Throughout the course of the work the miners and other inhabitants of the district assisted in every way possible. For the many favours and courtesies received the writer wishes to express his hearty thanks. Particular mention should be made of Corporal Waters of the Royal Northwest Mounted Police, who stored parts of the outfit; Captain Telford of the Royal Northwest Mounted Police, who kindly assisted with the preparations for the trip; Mr. Alex. Nichol who placed a building at the disposal of the party for the storage of supplies; and Mr. Robert Fisher who did much of the panning in connexion with the scheelite deposits.

E. W. Beltz was attached to the party as assistant and performed his duties in a very capable and satisfactory manner.

Location and Accessibility.

Mayo area takes its name from the town of Mayo, which is situated on upper Stewart river 180 miles above its mouth. The name has been somewhat arbitrarily applied to the part of the Duncan mining district for which the town acts as a base, and the area extends north from Stewart river to include Haggart creek and Dublin gulch, east to the foot of McQuesten lake and Duncan creek, and west to include Highet and Johnson creeks.

All parts of the area are readily accessible. Stewart river opens early in May and remains open, usually, until after the middle of October. During the open season of navigation, the White Pass and Yukon Route maintains a regular passenger and freight service to Mayo from Dawson. In winter there is a stage service between Dawson and Mayo, trips being made about once in three weeks. From Mayo a good wagon road has been constructed to Minto Bridge, a village lying 10 miles north of Mayo, and from this point roads radiate to all the important creeks.

The rates charged for freight vary greatly. From Dawson to Mayo the freight rate is $40 per ton. From Mayo to Highet creek the rate is 2 cents per pound, the distance being 22 miles, and from Mayo to Dublin gulch the rate is 10 cents per pound. Return freight is frequently carried at half the above rates, and winter rates are usually less than half the summer rates. Ore shipments are usually handled by contract, so that large shipments may be made from points well inland from Mayo, to smelters on the Pacific coast, for $45 to $50 per ton.

Previous Work.

During the summer of 1900 McConnell[2] made a geological examination of Stewart valley from Fraser falls down to Yukon river, and in 1904 and 1905 Keele[3] made a

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[1] Keele, J., "Upper Stewart River region," Geol. Surv., Can., Ann. Rept., vol. XVI, 1905, pt. C.

[2] McConnell, R. G., Geol. Surv., Can., Ann. Rept., vol. XIII, 1900, pp. 39A-43A.

[3] Keele, J., Geol. Surv., Can., Sum. Rept., 1904, pp. 18A-42A.
"Upper Stewart River region," Geol. Surv., Can., Ann. Rept., vol. XVI, 1905, pt. C.

geological reconnaissance. His reports and map contain much valuable information concerning the district. In 1913 McLean[1] sampled the lode deposits on behalf of the Mines Branch. In 1915 Cairnes[2] made a preliminary examination of the district, and returned in 1916 to spend a week investigating the placer deposits of tungsten minerals on Dublin gulch.

TOPOGRAPHY AND GENERAL GEOLOGY.

Mayo area lies entirely within the physiographic unit known as Yukon plateau and is situated well towards the eastern flank of the province. It is characterized by being subdivided into isolated mountain groups separated by broad, flat-bottomed valleys. The inter-stream areas are prevailingly flat-topped and stand at general elevations of from 4,500 to 5,000 feet, the elevation increasing slightly towards the east. These upland surfaces form parts of a former plain-like surface, which has been uplifted and dissected. Occasional peaks rise above the general level of the plateau surface and probably represent masses that were not reduced at the time of planation.

The district has been intensely glaciated, all but the upland having been covered by ice which rounded, smoothed, and scoured the valley walls, thus giving to the depressions typical U-shaped cross sections. The valleys are floored with glacial accumulations, through which the streams have cut, forming terraces, along which kettle holes are exceedingly numerous.

As a result of glaciation the drainage was disorganized and many striking changes have been forced upon the river systems of the area. From an economic standpoint, the most important of these changes are those which resulted in the formation of the canyons through which nearly all the smaller creeks enter the main streams. The formation of the canyons has probably been due to the rapidity with which the trunk channels have been cut through the glacial debris which gave rise to similarly rapid cutting on the part of the tributaries. It is in the canyons that many of the important mineral deposits have been located, since elsewhere bedrock is nearly everywhere covered by a mantle of superficial accumulations which renders the work of prospecting extremely difficult.

Geologically, Mayo area is not unlike other parts of the plateau. By far the greater part of the area is floored by the crystalline schists of the Yukon group[3] which are thought to be largely if not entirely of Pre-Cambrian age. In Mayo area these belong chiefly to the oldest division of the group, namely, the Nasina series[4] of McConnell and Brooks, and consist of gneissoid quartzites, quartz-mica schists, mica schists, graphite schists, hornblende schists, and crystalline limestone. In addition, a few areas of granite gneiss are intrusive into the schists.

At a few localities the older schists are cut by granitic rocks, chiefly grey, biotite granites, probably of Mesozoic age, and a few dykes of diabase, andesite, and rhyolite are known.

MINERAL RESOURCES.

Until quite recently gold-bearing gravels have been the only important source of minerals in Mayo area. In the year 1914, however, with the opening up of the extremely rich silver deposit at Galena creek, much more interest was directed to lode deposits and since that time a vigorous search for similar deposits has been under-

[1]McLean, T. A., "Lode mining in Yukon," Mines Branch, Dept. of Mines, Can., 1914, pp. 127-159.

[2]Cairnes, D. D., Geol. Surv., Can., Sum. Rept., 1915, pp. 10-34; 1916, pp. 12-20.

[3]Cairnes, D. D., "The Yukon-Alaska International Boundary," Geol. Surv., Can., Mem. 67, 1914, pp. 38-44.

[4]McConnell, R. G., "Report on the Klondike gold fields," Geol. Surv., Can., Ann. Rept., vol. XIV, 1901, pp. 12B-15B.

Brooks, A. H., "A reconnaissance in the White and Tanana River basins," U.S. Geol. Surv., 20th Ann. Rept., pt. 7, pp. 168-170.

taken with the result that several promising prospects have been discovered. In addition to silver-lead properties a vigorous search has been made to locate the source of the tungsten minerals occurring in the placer gravels on Dublin gulch. This search has resulted in the discovery, within the past year, of several veins carrying tungsten minerals. Arsenopyrite-gold veins and stibnite-arsenopyrite veins complete the list of deposits known.

Silver-Lead Properties.

General Statement. With the opening up of the Silver King deposit on Galena creek, much interest in argentiferous galena deposits was awakened. The Silver King mine closed down in the spring of 1918 after a short career as a producer, and when visited the workings were full of water and could not be examined. For a description of the property the reader is referred to Cairnes' report.[1] Though this mine has closed down the interest taken in this type of deposit has not waned and several promising prospects are being opened up, including deposits on Mt. Haldane (Lookout mountain) and Rambler hill.

Lookout Property. A number of claims are situated on Mt. Haldane, but serious work looking to the opening up of the deposits has been done on only one group, known as the Lookout property. This group, consisting of five claims, was staked by A. Johnson and bonded over to Messrs. J. E. Pickering, J. Greenfield, J. Anderson, and R. MacLennan. It is situated on a spur of Mt. Haldane on the western side of Bighorn creek, a tributary to the south fork of McQuesten river, at an elevation of 3,500 feet, or 125 feet above the level of the creek in this vicinity. A road has been constructed to the property, and comfortable buildings erected.

The development work includes two adits, an upper and a lower, both of which lie on the Lookout or central claim of the group. The upper adit is 50 feet in length and is terminated by a shaft following the inclination of the vein. The depth of this shaft is 25 feet measured on the slope. The lower adit lies 39 feet in elevation below and somewhat to the right of the upper. It is 59 feet long to the point where it taps the vein and from this point a drift follows the vein along the hanging-wall until immediately below the shaft, a distance of 87 feet. At this point a crosscut is being run to the foot-wall of the vein and it is intended to connect up the two sets of workings by a raise.

The country rock is a gneissoid quartzite and quartz mica schist on the Lookout claim, i.e., to the west of the creek, and on the eastern side of the creek gneissoid quartzites and greenstone schists occur. Farther to the east a small body of greyish granite porphyry intrusive into schists is to be found.

The vein follows a well-defined but slightly irregular fracture in the quartzites, striking from 120 degrees to 150 degrees (magnetic) and dipping from 45 degrees to 50 degrees to the southwest. The thickness of the vein where first encountered in the lower workings is 7 feet, but it widens continuously towards the shaft. The outline is thus probably lenticular, but insufficient work has been done to permit of an exact determination of the shape. The vein has been explored in length for only 87 feet, but various considerations render it almost certain that it is much longer.

The vein-filling consists of galena, limonite, manganite, pyrolusite, anglesite, quartz, and occasional specks of copper minerals, usually oxidation products. Angular fragments of the shattered country rock are also included. The hanging-wall is sharply defined and is marked by 1 to 6 inches of gouge, frequently showing an inch or more of impure graphite. The foot-wall is not very well marked, the mineralization extending into the country rock as much as 10 feet beyond the vein proper, in veins or tongue-like fissures. The distribution of the minerals in the vein is exceedingly irregular and follows no definite rule that has been recognized. The galena occurs plentifully along the foot-wall associated with limonite and manganese minerals. In such places it is coarsely crystalline and not particularly rich in silver. At intervals through the vein,

[1] Cairnes, D. D., Geol. Surv., Can., Sum. Rept., 1915, pp. 27-28.

but most frequently close to the hanging-wall, are small, irregular streaks of finely crystalline galena high in silver. The limonite is found thoughout the vein. Manganese minerals such as pyrolusite and manganite are confined to the foot-wall.

The workings lie entirely within the oxidized zone. Owing to the frozen condition of the ground oxidation must have been accomplished prior to the formation of the frost zone, in which the present workings lie, as the frozen ground prevents the circulation of meteoric waters necessary to accomplish the alteration. It is, therefore, unlikely that the depth of the zone of oxidation bears any relation to the present ground water-level and probably very little to the present topography. Further the oxidation has been very incomplete.

Six samples were taken. No. 1 is a sample of all the material up to one foot from the hanging-wall; No. 2 of all material up to 2 feet from the floor of the shaft, the foot-wall not being visible; No. 3 to include the remainder of the vein lying between these two. These three samples were taken at the bottom of the shaft. No. 4 is a sample to give an idea as to the content of the foot-wall taken where the vein was first encountered in the lower adit. No. 17 is a sample of the working face taken arbitrarily on August 6. No. 18 is a sample of highly manganiferous material from the foot-wall. These were assayed and the results are listed below.[1]

No.	Gold.		Silver.		Total value gold and silver.	Per cent lead.	Remarks.
	Oz. per ton.	Value per ton.	Ozs. per ton.	Value per ton.			
		$		$	$		
1	0·02	0.40	34·38	34.38	34.78	20·06	
2	Trace.	.....	26·20	26.20	26.20	25·15	
3	0·03	0.60	62·85	62.85	63.45	30·14	
4	Trace.	.....	11·10	11.10	11.10	7·20	High in manganese.
17	Trace.	.....	8·20	8.20	8.20	10·66	
18	Trace.	.....	4·50	4.50	4.50	1·09	High in manganese.

In addition to the vein on the Lookout claim two and possibly three other veins as yet undeveloped occur on the Wolf claim on the eastern side of the creek. These extend up over the ridge on to adjoining claims. As no development work had been done it was impossible to obtain full particulars, especially as the surface was covered with superficial accumulations. Only the weathered outcrop of two of the veins was visible and was found to be made up of limonite and manganese minerals, such as pyrolusite and manganite, like the outcrop of the Lookout vein. From the outcrop, the veins were traced up hill by means of float for a distance of over 2,000 feet. The two veins where exposed are thin and strike about magnetic north, and dip at 45 and 60 degrees to the west respectively. They probably intersect, therefore, a short distance below the surface.

Three samples were taken—Nos. 19, 20, and 21—to represent all the vein matter in sight near the outcrop, including both float and material in place. These gave the following results on assay.

No.	Gold.		Silver.		Total value gold and silver.	Per cent lead.	Per cent Mn.
	Oz. per ton.	Value per ton.	Ozs. per ton.	Value per ton.			
				$	$		
19	Trace.	.....	5·60	5.60	5.60	0·20	Not determined.
20	Trace.	.....	Trace.	.....	.....	0·25	Not determined.
21[2]	Nil.	.....	12·66	12.66	12.66	Not determined.	24·15

[1] All assays by Wm. Sime, Territorial Assay Office, unless otherwise stated.

[2] Assay by Mines Branch, Dept. of Mines, Ottawa.

These results on the whole are encouraging. Though it appears that the greater part of the ore will require concentration before shipping, the ore-bodies appear to be of sufficient size to warrant the erection of a small plant for milling. With very little more work the size of the ore-bodies can be determined and then it would be possible to decide if the erection of a mill was justified. Owing to the superficial accumulations the outcrop could not be traced for any distance save by means of float which is unsatisfactory, but the Lookout vein appeared to be persistent.

Other Properties. Several prospects have been staked along the strike of the Lookout vein, but on these no mineral has as yet been discovered. Other prospects are located on the eastern face of Lookout mountain, but insufficient work has been done as yet to determine their value.

Rambler Hill Property. Rambler hill is situated about 6 miles east of the foot of McQuesten lake, and on it a prospect known as the Rambler Hill property occurs well up on the hillside within 300 feet of the summit at an elevation of about 5,000 feet. The workings lie entirely above timber-line. Eight claims in all are held, owned by Messrs. A. Martin, A. Lamb, A. R. Thompson, H. Colley, J. Alverson, G. Forey, J. Lake, and J. Robertson, each of whom own an undivided eighth interest.

There is no road to the property. A wagon road reaches Galena creek some 20 miles from the property and if needed could be easily extended to the prospect, passing for the greater part of the distance through a glacial moraine, thus affording a firm, dry bed on which a road could be constructed with ease.

The country rock consists of mica schists cut by large dykes of greenstone approaching a diabase in composition. The vein is situated close to one of these dykes, strikes approximately 70 degrees (magnetic), and is nearly vertical. The development work consists of a shaft 50 feet deep and a crosscut 10 feet long. Very little could be seen in these workings, particularly the shaft at the time of the writer's visit, as the walls were covered with ice. The total thickness of the vein is 12 feet, but this includes several horsts of barren rock.

The vein filling consists of limonite, galena, pyrite, quartz, cerussite (?), anglesite (?), malachite, and chalcopyrite. The limonite makes up by far the greater mass of the deposit. Included in it are small nodules of galena, generally about one-quarter inch in diameter, coated with oxidation products, probably cerussite and anglesite. The quartz occurs as crystals lining vugs or cavities and also as large masses. Chalcopyrite and its weathering product malachite are both rare, but occur in small disseminations, as also does the pyrite. The workings lie entirely within the oxidized zone of the deposit. The most noteworthy fact concerning this is that oxidation becomes more complete with depth. This is especially true of the galena. Near the surface and extending downwards to a depth of 37 feet are large masses of galena coated with limonite. Below, these disappear leaving only small nodules of galena. Three samples were taken, Nos. 14, 15, 16. No. 14 is a sample of the whole vein in the crosscut, including much waste; No. 15, a sample of the richer material, chiefly limonite and galena near the surface; and No. 16, a sample across 6 feet of the better mineralized portions of the vein in the crosscut. These were assayed and found to contain:

No.	Gold.		Silver.		Total value gold and silver.	Per cent lead.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.		
		$		$	$	
14	Trace.	.....	0·60	0.60	0.60	Nil.
15	Trace.	.....	15·68	15.68	15.68	51·45
16	0·01	0.20	3·94	3.94	4.14	Trace.

Insufficient work has as yet been done to give a true idea as to the extent of the deposit. The outcrop of the vein is concealed by superficial deposits so that it is

practically impossible to trace it on the surface. The width of the mineralized zone and the content of silver in the unaltered galena (sample 15) indicate a prospect with some promise. With regard to the low values disclosed by samples 14 and 16, it was, of course, hardly likely that where the leaching has been so thorough, any values would be found.

The deposit is unfortunately situated with regard to transportation. The nearest point to which a wagon road has been constructed is Galena creek, and to continue this to the property would involve the expenditure of a large sum of money. Until sufficient work is done to prove the property to be of economic importance, such an expenditure would not be justified. On the other hand, a winter road could be constructed across McQuesten lake to the head of Beaver river. This would afford water transportation as far as Fraser falls, but some doubts are expressed as to the feasibility of this route, as the Beaver would hardly be navigable except in extremely high water.

Arsenopyrite-Gold Veins.

In addition to the silver-lead veins a number of other mineral veins occur in the area, by far the greater number of which may be grouped into the one class here designated as arsenopyrite-gold veins. The most important locality is Dublin gulch, where a large number of these veins have been discovered and where considerable development work has been done on the veins.

Dublin Gulch. The rocks outcropping in the vicinity of Dublin gulch belong to two entirely distinct groups. The oldest of these is a series of schistose and gneissoid rocks composed of quartzites, quartz-mica schists, mica schists, amphibolites, crystalline limestone, and some granite gneiss. Piercing these is a body of grey biotite granite, about 3 miles long by 1½ miles wide. The arsenopyrite veins are situated at or near the contact of this body, some lying in the schist, others in the granite, and some passing from one rock into the other without apparent change. The veins as a rule are narrow, seldom exceeding 2 feet in thickness and averaging much less, and are usually low grade. The outcrops are much weathered and are heavily stained with a greenish arsenate of iron. No attempt was made to sample these deposits thoroughly as this had already been done by McLean and Cairnes,[1] and attention was paid only to veins on which recent work has been done.

The Stewart-Catto Group. The Stewart-Catto group is composed of five claims and two fractions, all of which have been crown granted. These claims are located on the left side of Dublin gulch between Stewart and Olive gulches and are owned by J. S. Stewart and Dr. William Catto. About ten veins in all have been discovered but nearly all the development work has been done on three, which are known as the Green, Victoria, and Cabin veins. A number of trenches exposing the other veins have been dug, but most of these have so caved in that the veins could not be seen.

The Green vein is exposed on the left bank of Olive gulch. A considerable amount of development work has been done on it, including about 260 feet of tunnel and a raise of 27 feet, in addition to numerous open-cut trenches. The underground work includes an adit 60 feet long, which really drifts on the vein for about 50 feet. At the end of this crosscut a drift is continued along the general strike of the vein for 130 feet and from the end of this drift a 27-foot raise has been driven. Also from the main drift two small crosscuts, 40 and 30 feet long respectively, have been driven. The vein strikes almost due east and west and is nearly vertical in altitude. It varies greatly in thickness, ranging from 10 inches to 3 feet and averages, probably, about 14 inches. The vein filling is arsenopyrite in a quartz gangue. One sample, No. 24, was taken, this being cut at intervals along the vein so as to represent as closely as

[1] McLean, T. A., Op. cit., pp. 127-159. Cairnes, D. D., Geol. Surv., Can. Sum. Rept., 1915. pp. 29-33.

possible the average of the vein. For the sake of comparison four samples taken by Cairnes, Nos. 1, 2, 3, and 4, are included in the list given below.

No.	Gold.		Silver.		Total value gold and silver per ton.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.	
		$		$	$
24	0·35	7.00	0·65	0.65	7.65
1	0·40	8.00	0·52	0.52	8.52
2	0·56	11.20	1·09	1.09	12.29
3	0·10	2.00	0·50	0.50	2.50
4	Trace.	.....	Trace.	.....	.....

On the Victoria vein a crosscut has been driven into the hill for a distance of 140 feet. This encounters two veins at distances of 85 and 100 feet, which are known as the Victoria vein and No. 2 vein, respectively. The Victoria vein strikes due east and is almost vertical; No. 2 vein strikes south 43 degrees west and is also nearly vertical. Drifts have been run along these two veins. On the Victoria vein the drift is 27 feet long to the right of the crosscut and 30 feet long to the left. In this drift the vein is 12 to 18 inches thick, and is somewhat porous and decomposed, being heavily stained with greenish iron arsenate. The filling is mainly quartz, well mineralized with arsenopyrite and pyrite. Near the end of the left drift the vein narrows rapidly and is joined by No. 2 vein, which at this point is over 4 feet thick but rather barren of mineral. One sample was taken of each of these veins—No. 22 from the Victoria vein, sampled at intervals along its length, and No. 23 from No. 2 vein. These were assayed and the results are listed below.

No.	Gold.		Silver.		Total value gold and silver per ton.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.	
		$		$	$
22	0·61	12.20	8·99	8.99	21.19
23	0·44	8.80	0·56	0.56	9.36

The Cabin vein is exposed on the surface by a line of open-cuts. In addition, an adit has been driven into the hill, which encounters the vein at 132 feet. The vein strikes south 44 degrees west (astronomic) and dips to the southeast at 65 degrees. Almost immediately beyond the point where first encountered the vein is cut off by a fault and in order to find it again 312 feet of crosscuts have been run, ultimately picking up the vein. Two samples were taken, Nos. 25 and 26. No. 25 represents the vein material where picked up again beyond the fault and No. 26 the vein close to the fault zone. These were assayed and the results are given below.

No.	Gold.		Silver.		Total value gold and silver, per ton.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.	
		$		$	$
25	0·27	5.40	5·13	5.13	10.53
26	0·76	15.20	1·44	1.44	16.64

One vein recently discovered on the Victoria claim merits attention, due to the fact that from surface indications it belongs to a different type, being most likely a

pyrite-gold-quartz vein. This vein is exposed in an open-cut and has a strike of south 34 degrees east (astronomic) and a dip of 52 degrees to the southwest. The thickness where exposed is 2½ feet. The minerals of the vein-filling are pyrite, limonite, siderite, quartz, and free gold. The better mineralized portion is confined to 12 inches in the centre of the vein. This was sampled and gave the following results:

No.	Gold.		Silver.		Total value per ton, gold and silver.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.	
		$		$	$
42	0·16	3.20	5·69	5.69	8.89

The Olive, Blue Lead, Eagle, and Carscallen groups were not examined as no work has been done on them for several years. For a description of these properties the reader is referred to the report by Cairnes.[1]

There is sufficient ore of a milling grade in sight on Dublin gulch to warrant the erection of a small milling plant in the vicinity. There seems to be no reason why concentrates of shipping grade could not be made from the deposits described above if a suitable plant were erected, and many of the deposits could doubtless be worked at a profit. It is evident, however, that none of the ores as known at present are of sufficient grade to pay for shipping to an outside point for treatment.

Christal Creek. Another property with veins of a similar type is situated on Christal creek, a tributary to the south fork of McQuesten river, entering the latter about 15 miles below McQuesten lake. Christal creek enters the McQuesten River valley through a canyon, and it is in this canyon that the veins are exposed. The prospect is the property of Axel Erickson and Fred. Swanson, and consists of one claim.

Two adits have been driven into the hill where the vein croppings are exposed. The upper adit encounters a number of small veins, the lower adit is barren of any mineral showings. The upper adit is 34 feet long and in that distance encounters two veins which will be called Nos. 1 and 2. From the end of the adit two crosscuts have been driven to the left and right. The left crosscut encounters two veins or stringers, Nos. 3 and 4. Vein No. 3 strikes south 54 degrees east (astronomic) and is vertical; vein No. 4 strikes south 20 degrees east and dips at 50 degrees to the southwest. Both are less than 5 inches thick. The right crosscut encountered two veins, No. 5 and the "Shaft" vein. Vein No. 5 is poorly exposed, being visible only in the floor of the drift. The Shaft vein strikes south 74 degrees east (astronomic) and dips to the northwest at an angle of 60 degrees, and in reality is simply a zone of shearing in the country rock along which there has been an impregnation of sulphides, in individual crystals and in small bunches. Veins 1, 2, 3, 4, and 5 are arsenopyrite-gold quartz veins and owing to the fact that they are thin and not very persistent are not likely to prove of economic value. In the Shaft vein, so-called because a small shaft following the inclination of the shear zone has been sunk, the thickness of the shear zone is 3 feet, and scattered irregularly through the rock are small bunches of quartz, galena, arsenopyrite, pyrite, and zinc blende. Eight samples were taken. No. 5 is a sample of vein No. 1; No. 6, a sample of vein No. 4; No. 7 a sample of vein No. 2; No. 8, of vein No. 3; No. 9 is a sample of picked material from the foot-wall of the Shaft vein, including all the best mineralized parts; No. 10 is a sample across the Shaft vein at the

[1] Cairnes, D. D., Geol. Surv., Can., Sum. Rept., 1915, pp. 29-34.

bottom of the shaft; No. 11, a sample across the same vein at the top of the shaft; and No. 12, a sample of vein No. 4. These were assayed and the results are listed below.

No.	Gold.		Silver		Total value gold and silver.	Per cent lead.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.		
		$		$	$	
5	0·24	4.80	1·21	1.21	5.01	nil
6	Trace	.....	0·40	0.40	0.40	nil
7	Trace	.....	Trace	.....	.....	nil
8	0·27	5.40	0·73	0.73	6.13	nil
9	0·04	0.80	10·16	10.16	10.96	3·74
10	Trace	.....	0·90	0.90	0.90	nil
11	Trace	.....	0·70	0.70	0.70	nil
12	Trace	.....	0·25	0.25	0.25	nil

Stibnite-Arsenopyrite-Quartz Veins.

Quartz veins carrying much stibnite and a little arsenopyrite have been located on the Highet Creek-Johnson Creek divide. The chief outcrop occurs on Highet dome, a hill lying at the head of Rudolph gulch which is a tributary to Johnson creek. Several small pits have been sunk, but at the time of the writer's visit these had largely become filled in so that very little could be seen of the vein.

The country rock is a gneissoid quartzite, which is intruded by several small bodies of grey biotite granite, and the deposit is situated about 2,000 feet from the contact. The full width of the vein is not visible, but from the blocks of material which have been removed it approaches 2 feet in thickness. The vein-filling consists of quartz and stibnite with a little disseminated arsenopyrite, and some of the yellowish oxidation products of antimony. One sample was taken. This is intended to represent all the vein material in sight, including that on the dump. The results of the assay are given below.

No.	Gold.		Silver.		Total value gold and silver.	Per cent antimony.
	Oz. per ton.	Value per ton.	Oz. per ton.	Value per ton.		
				$	$	
49	Nil.	.....	0·80	0.80	0.80	33·93

On other claims in the vicinity float has been discovered that must have been derived from thick veins of antimony, but no such veins have been discovered.

Much better deposits of antimony occur in southern Yukon[1] and these are much more favourably situated with regard to transportation than veins in the Mayo area. Notwithstanding this they cannot be worked at a profit under present conditions.

Tungsten Deposits.

In the year 1916 the placer scheelite deposits on Dublin gulch attracted considerable interest, as the demand for scheelite and other tungsten minerals became pressing. The heavy grey sand which collected in the sluice boxes during the process of washing the auriferous gravels was consequently saved and as a result several tons of high grade concentrates have been shipped. In the years 1917-18, chiefly through the

[1] Cairnes, D. D., "Wheaton district," Geol. Surv., Can., Mem. 31, 1912, pp. 113-129 Geol. Surv., Can., Sum. Rept., 1915, pp. 46-49.

efforts of Mr. Robert Fisher, the sources of this tungsten mineral were found and veins carrying scheelite are now being opened up. The writer was concerned mainly with the lode deposits, but some attention was given also to the placers.

Placer Deposits. The occurrence of scheelite in the auriferous gravels of Dublin gulch was first mentioned by Keele[1] and later by other writers, but no attempt was made to save this mineral. After the visit by Cairnes in 1916[2] the miners commenced to save it, but owing to misunderstandings which have since been removed only relatively small shipments were made. This spring (1918) over a ton of high grade concentrates were shipped, and a shipment of the same amount will probably be made before the close of navigation.

At the present time six men are engaged in working the placer gravels on Dublin gulch and are producing scheelite in addition to gold. A minor amount of wolframite is obtained with the scheelite.

Near the mouth of Dublin gulch four men, F. Cantin, P. Cantin, L. Cantin, and J. Letourneau, are working as partners on claims Nos. 1, 2, 3, 4, 5, 8, and 9 above Discovery, which is usually taken as the mouth of the creek. The depth to bedrock is from 8 to 12 feet and the width of the paystreak is about 100 feet. The ground is worked by open-cutting and sluicing, the material left on bedrock after sluicing being shovelled into boxes and washed. The gold obtained, as shown by the average for the season, is from 50 to 75 cents per cubic yard and the scheelite recovered averages from 0·8 to 1·2 pounds per cubic yard. In addition to scheelite the concentrates contain wolframite, ironstone, garnet, and other heavy minerals. Much of the wolframite is at present discarded with the ironstone. Two samples of this discarded material were taken. These assayed 51·0 and 50·75 per cent WO_3. A total of 2,500 feet of this ground remains to be worked, and the yield should be from 20 to 30 tons of concentrates. In addition to this there is much ground which was worked over in the early days when the scheelite was discarded, but it is doubtful if it would pay to work these tailing piles from which most of the gold has been extracted.

No work is being done between claims Nos. 9 and 29. On claims 29, 30, 30A, 31, 32, 33 Robert Fisher is working alone. The chief workings are situated on claim No. 30A. A small open-cut is in progress, but at the time of the writer's visit the water supply was insufficient for the purpose, and it was only by means of damming the creek and releasing the flood at intervals that progress could be made. Bedrock had not been reached, but panning showed that scheelite and wolframite were present in quantity, not only in the gravel, but also in the muck overlying it. Panning which was continued up Dublin gulch and up Olive gulch for a short distance showed that scheelite was as abundant in the tributary as in the main stream. Insufficient work has been done to permit of an estimate of the probable recovery, but the results obtained show that scheelite is present in quantities fully as great as in the workings below.

On claims Nos. 34 and 35 Wm. Steinberger has started an open-cut. As the supply of water is insufficient, Mr. Steinberger has installed an automatic dam which stores the water until a full head is obtained, discharges, and then closes automatically. The gate is 5 by 3 feet and the water at the moment of discharge has a head of 3 feet 4 inches. This device is very effective as the volume and velocity of the flow is great enough to move large quantities of material; but in low water it discharges only twice in twenty-four hours. Work on the cut had barely commenced in midsummer, but panning showed as much as one-quarter ounce of scheelite to the pan near the surface and the amount probably increases as bedrock is approached.

No work is being done above claim 35, although scheelite undoubtedly occurs in quantity. The water supply, however, is inadequate and it is only by impounding water from the melting snow that work could be carried on successfully.

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[1] Keele, J., Geol. Surv., Can., Sum. Rept., 1904, pp. 18A-42A.

[2] Cairnes, D. D., Geol. Surv., Can., Sum. Rept., 1916, pp. 12-19.

The chief difficulties in the way of successful placer mining for scheelite on Dublin gulch are lack of water and the large number of huge granite boulders which have to be moved. The first difficulty might be overcome by impounding the snow water in the heads of the gulches, as much of this runs off at present before the ice on the creek has disappeared. The second might be overcome by installation of steam derricks for the handling of the boulders. On the whole, however, it is doubtful if mining for scheelite alone would prove highly profitable. Wages or possibly slightly better might be made, but it is where gold is concentrated along with the tungsten minerals that mining operations are likely to prove successful.

Lode Deposits. Scheelite has been found at a number of points in its original associations, and a number of small surface pits and trenches have been dug exposing the veins at these localities. The discovery of these veins is chiefly due to the prospecting work of Mr. Robert Fisher who facilitated their examination in every way possible.

General Geology. Dublin gulch is floored largely by the older crystalline schists previously described, but these are cut by a body of grey biotite granite, 3 miles long by 1 mile wide, crossing the creek diagonally near the mouth of Bum Boy gulch. From what is known of the distribution and characteristics of the scheelite deposits it seems probable that the source of the mineral lies in the granitic magma from which it was concentrated into veins during the latest stages of consolidation of the igneous mass. A number of localities were examined and for convenience these may be grouped as follows:

Quartz veins. (*a*) In the granite. (*b*) In the surrounding rocks.

Pegmatites.

Quartz Veins in the Granite. The veins of this group are found at far the greater number of the known localities, and were formed probably as one of the latest stages of igneous intrusion. The veins often occur in three sets of fissures approximately at right angles to one another and vary in thickness from 1 to 6 inches. None of them has so far been traced for any considerable distance. The scheelite occurs as crystals both in the veins and in the wall rock adjacent to them. Quartz is usually the only gangue mineral. Calcite is sometimes present and white mica is also found affording a transition between these veins and the pegmatite deposits.

Description of Localities. The first occurrence of this class visited lies on the Bum Boy claim at the head of Bum Boy gulch. This vein was located by Robert Fisher who traced the scheelite up the gulch to the outcrop by means of panning. The granite at this point is covered by 5 feet of overburden of which 2 feet is soil and the remainder the products of decomposition in place of the granite. In this decomposed material even the grain of the original rock is still visible, however. Owing to superior resistance, the veins in it have remained unaltered. This decomposed granite carries much scheelite and at first it was thought that the whole overburden on the upland might prove to be an economic source of this mineral, but panning tests showed that the scheelite is restricted to the vicinity of veins. This point should be remembered in prospecting for other deposits.

Three quartz stringers are exposed. Two of these are nearly vertical and intersect at approximately right angles, and the third is horizontal. These stringers have a maximum thickness of 2 inches, and the scheelite occurs in crystals and grains in the quartz and adjacent wall rock. Two samples were taken. No. 27 represents the vein matter exposed in the cut and No. 28 the residual soil across a width of 5 feet, 2½ feet on each side of the vein, but not including any vein material. The results of the assays are given below.[1]

No.	Gold.		Per cent WO_3.
	Ozs. per ton.	Value per ton.	
27	Nil.	Nil.	1·80
28	Nil.	Nil.	0·85

[1] All tungsten assays by Mines Branch, Dept. of Mines, Ottawa.

A second occurrence has been located by Robert Fisher, 1,500 feet to the east of the veins on the Bum Boy claim. In this place there are three quartz stringers with thicknesses of from 4 to 5 inches. The scheelite occurs both in the veins and in the wall rock generally in crystals, some of which attain a length of over 1 inch. The decomposed rock in the vicinity of the veins contains scheelite, which in some places amounts to nearly 1 per cent of the mass. Two samples were taken: No. 29 representing the vein material and No. 30 the wall rock for 2½ feet on each side of the veins but not including any of the vein material. The assays of these samples are given below.

No.	Gold.		Per cent WO_3.
	Ozs. per ton.	Value per ton.	
29	Nil.	Nil.	1·70
30	Nil.	Nil.	1·20

The third occurrence lies practically on the line between the Bum Boy and the Cairnes claims, and is possibly the most promising of all those so far located. There are two veins striking south 50 degrees east and south 50 degrees west respectively, and both dip steeply at 60 degrees. Three samples were taken. No. 33 is a sample of the first or more prominent vein which has a thickness of 6 to 8 inches. No. 34 is a sample of the granite adjoining the vein 1½ feet on each side. No. 35 is a sample of the adjacent granite 2½ feet on each side of the vein and No. 36 a sample of the second vein. Assays of these samples gave the following results.

No.	Gold.		Per cent WO_3.
	Ozs. per ton.	Value per ton.	
33	Nil.	Nil.	2·60
34	Nil.	Nil.	—
35	Nil.	Nil.	Trace
36	Nil.	Nil.	10·10

Veins in Rocks Adjacent to the Intrusive. Only two instances of veins of this class were observed by the writer, both on the slope facing Lynx fork, a tributary to Haggart creek. The country rock is a banded gneiss composed of alternate bands of dark greenish hornblende gneiss and light-coloured mica gneiss, with occasional bands of crystalline limestone. The deposits are situated within the contact zone of the intrusive. As the deposits are similar only one will be described.

This vein lies on the Vernon claim overlooking Lynx fork and directly opposite the head of Dublin gulch. At this point a quartz vein, having a thickness of 4 inches, cuts the banded gneiss. Scheelite occurs only sparingly in the vein and is far more abundant in the greenstone adjacent, where crystals about one-half inch in length may be seen. Two samples were taken, Nos. 38 and 39; of these No. 38 represents the vein and No. 39 the mineralized wall rock. Assays of these gave the following results.

No.	Gold.		Per cent WO_3.
	Ozs. per ton.	Value per ton.	
38	Nil.	Nil.	1·25
39	Nil.	Nil.	3·40

Pegmatite Veins. The pegmatite deposits are closely associated with the quartz veins in origin; and, intermediate phases between the two occur. Only one instance

of a pegmatite carrying appreciable amounts of scheelite has been found. This occurs on the McLean claim, at the head of Dublin gulch. On this claim there is a vein of pegmatite at least 1 foot in thickness and possibly slightly more, as owing to the filling of the cut with debris very little of the deposit could be seen. The pegmatite is a coarsely crystalline mass of white mica and quartz, with isolated patches of feldspar. Locally, however, a greenish hornblende makes up the bulk of the deposit. Associated with these pegmatites are tourmaline, siderite, graphite, and wolframite (?), though all of these minerals are not found at this particular locality. The scheelite occurs as crystals in the pegmatite, both in the mass and lining vugs or cavities. Small ramifying quartz veins cutting the dyke also carry scheelite.

Sample No. 37 was taken across the width of the vein exposed. It was assayed and the results are given below.

No.	Gold.		Per cent WO_3.
	Ozs. per ton.	Value per ton.	
37	Nil.	Nil.	6·35

Insufficient work has as yet been done on the deposits to permit of making a fair estimate of their value. Veins have been found at a few localities only; but it is probable that when the area in which the granite outcrops has been more thoroughly prospected, many more will be located. The veins as a rule are thin, but at some of the localities examined they occur sufficiently close together to form mineralized zones which possibly could be profitably exploited. If the price paid at present for tungsten should continue, it seems probable that some of these veins could be mined; but more development work is necessary in all cases to ascertain if sufficient ore is available to warrant the erection of a mill. The samples show that none of the vein material so far discovered is rich enough to pay for shipment to outside points for treatment, and consequently concentration is necessary.

There are two drawbacks which will retard the rapid development of mining on Dublin gulch; these are the limited supply of water and the remoteness of the district. Sufficient water could probably be obtained by impounding the water from the melting snow near the heads of some of the smaller gulches. Owing to the remoteness of the district, it is difficult and expensive to freight in supplies and equipment, which at present can be handled only in the winter when the sleighing is good. In the same way the output of scheelite or other ores can be freighted out only in the winter, so that for ores mined in the spring or summer a full year must elapse before returns are received. The cost of building a suitable summer road would be very high.

Scheelite Deposits on Johnson and Highet Creeks. Scheelite was first detected on Highet and Johnson creeks, as it has been on Dublin gulch, by its presence as a heavy grey sand in the sluice boxes. The amount is not nearly as great as in Dublin gulch, but the discovery has led to some prospecting for it, chiefly by Mr. P. Minton.

Scheelite was found on Discovery claim on Johnson creek and was traced up Sabbath creek, a tributary entering Johnson about 3 miles from its mouth. Tributaries entering Sabbath creek also carry scheelite, but more particularly a small gulch entering Sabbath creek 1½ miles above its mouth. This is locally known as Scheelite gulch.

The gravels on Sabbath creek, Scheelite gulch, and the upland were panned, and it was found that the scheelite is practically confined to the areas of granitic rocks. In no case were any very rich spots found, and as it is possible to mine only very small parts of the creeks, on account of lack of water, it is reasonable to infer that Johnson creek and its tributaries cannot be reckoned as an economic source of placer scheelite. Even on those parts of the creeks where water can be obtained masses of huge boulders occur, which would render mining operations difficult and costly.

On the tributaries of Highet creek similar conditions obtain.

There is, however, no reason why scheelite should not be found in place in the area of granitic rocks which outcrop in this locality. Those places in which scheelite is most abundant on the upland are almost certain to lie directly over or slightly down hill from veins carrying this mineral, and if prospecting is carried out with this in mind, deposits of scheelite can almost certainly be located in place.

SILVER-LEAD DEPOSITS OF THE TWELVEMILE AREA, YUKON.

By W. E. Cockfield.

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INTRODUCTION.

The writer had an opportunity of visiting the Twelvemile area after the close of the season's work in the Mayo area. This visit was only in the nature of a preliminary examination, to gain some idea as to the extent and value of the mineral deposits, and other details which might prove useful for the purposes of comparison with the deposits of Mayo.

The writer wishes to express his indebtedness to the officers of the Yukon Gold Company who afforded him accommodation at their camps and to the employees of the same company for the courtesy and attention with which he was everywhere received.

Galena carrying high values in silver has been known for a number of years to occur in this area, but until quite recently only float had been found. Veins were recently discovered in the canyon of Spotted Fawn creek and a large number of claims were staked.

Location and Accessibility.

The deposits lie within what may be termed Twelvemile area. The Chandindu or Twelvemile river is a tributary to Yukon river, joining it 17 miles below Dawson. It forks 28 miles above its mouth into two branches known as the Twelvemile and Little Twelvemile. The deposits are situated on Spotted Fawn gulch which joins the Little Twelvemile 11 miles above its mouth. The power plant of the Yukon Gold Company is situated at the forks of the Twelvemile, and from this point a wagon road has been constructed to Dawson, a distance of 40 miles. This road joins the road up the Klondike valley in the vicinity of Bear creek. From the power-plant, the flume affords a good footpath to within 6 miles of the property. From the end of the flume there is a pack trail. In winter, supplies may be hauled up the valleys of the Twelvemile and Little Twelvemile.

TOPOGRAPHY AND GENERAL GEOLOGY.

The region lies wholly within the physiographic unit known as Ogilvie range. This is a spur of the Rocky Mountain system which stretches from the headwaters of Stewart river to Yukon river at the 141st meridian. This mountainous belt presents an aspect very different from that of the Yukon plateau. Beyond a somewhat general accordance of summit level it gives no evidence of ever having been planated, and probably existed as an upland tract at the time of the planation and subsequent uplift of the Yukon plateau. The range has everywhere a rugged appearance and is composed of a series of sharp ridges separated by broad, deeply-cut valleys.

The district has been intensely glaciated and all but the highest summits have been overridden by ice. The valley spurs have been truncated and the walls rounded,

giving to the depressions a U-shaped outline which is characteristic. The valleys all terminate in cirque-like depressions, holding small lakes which are being rapidly filled in and reclaimed. As a result of post-glacial changes in the drainage system the streams have cut narrow trenches in the older valley bottoms, so that the valley walls are lined with rock-cut benches. Quite frequently these narrow to cleft-like canyons, and it is in one of these canyon cuttings that the ore-bodies have been located.

The geology, as might be expected, differs widely from that of the Yukon plateau. The older crystalline schists are nowhere in evidence, and the greater part of the region is floored by sediments, which although greatly altered, have not developed a gneissoid or schistose structure. Intrusive into these are numerous bodies of acid and intermediate rocks. The sediments are divided roughly into two series, a lower and an upper. The lower consists of red and green slates, phyllites, banded cherts and quartzites, and some limestone. Rhythmical colour banding is quite frequent. The beds dip to the eastward at comparatively low angles. Overlying them, apparently conformably, is an exceedingly thick series of greyish quartzites and black slates, with intercalated impure sandy limestones. None of these beds so far as observed is fossiliferous. The lower beds correspond both lithologically and stratigraphically with parts of the Tindir group[1] of Cairnes and it seems probable that they belong to this group. Concerning the upper series there is more doubt, but it probably corresponds also to parts of the same group. If such is the case the rocks are entirely pre-Middle Cambrian in age and probably belong entirely to the Pre-Cambrian. They are cut by intrusions of granite, diorite, granodiorite, andesite, and allied rocks.

ORE DEPOSITS.

The ore deposits occur in the canyon of Spotted Fawn gulch, a tributary to the Little Twelvemile. A number of claims have been staked, but up to the present, ore has been discovered in place on only two, the Ophir and the Galena Farm. These claims form parts of a group owned by D. B. Cole, Chris. Fothergill, C. Sproule, W. Melville, W. Elliott, and Judge Craig. At this point a dyke of porphyritic greenstone breaks through the quartzites and slates. The dyke is exposed for about 1,200 feet along the strike and has a width of 300 to 500 feet. Definite measurements of the width could not be obtained owing to superficial deposits. The veins are small fissures in the greenstone dyke, apparently being confined to it and not extending into the quartzites and slates. They traverse the dyke in a direction nearly parallel to one system of joint planes, and are characterized by splitting, chambering, and brecciation, making it apparent that they were formed under relatively slight load, probably at no great depth below the surface.

At the first locality examined, on the Ophir claim, there are two veins, nearly parallel in strike and about 4 feet apart, on the outcrop. These veins dip at different angles, and intersect about 6 feet below the surface. The maximum thickness of one vein is 16 inches and of the other 10 inches. From the thickest part both pinch rapidly in either direction, thinning to less than an inch in a distance of 25 feet. The vein-filling is a coarsely crystalline galena with pyrite and calcite, with included angular fragments of the greenstone. These are frequently partly replaced by galena. Both walls of the veins are sharply defined, very little of the ore mineral extending beyond the wall. Small specks of galena do, however, occur in the wall rock, but they are exceedingly rare. The veins were originally covered with 2 to 5 feet of gossan, composed of limonite and other oxidation products; but this gossan has been removed during the development work. Below this the galena is stained a rusty brown colour on the surface.

About 75 feet upstream from this showing, another vein occurs on the Ophir claim. It is similar in many respects to those already described, but is thinner and much more sparingly mineralized.

[1]Cairnes, D. D., "The Yukon-Alaska International Boundary," Geol. Surv., Can., Mem. 67, 1914, pp. 44-58.

In addition to the veins, many of the joint planes of the dyke have galena and calcite deposited in them. These are interesting as showing how intense mineralization was in this vicinity, but owing to their size they can not be considered of economic importance.

Four samples were taken, all of them from the first locality described, which is considered as the most promising showing on the property. No. 50 is intended to represent the average of the larger vein at this locality; No. 51, the intersection of the two veins; No. 52, a sample cut at intervals along the smaller vein at the same place; and No. 53, a cut taken across the two veins, including the wall rock lying in between, to give an idea of the content per ton of material mined. These were assayed and the results are listed in the following table:

No.	Gold.	Silver.		Lead per cent.
	Oz. per ton.	Oz. per ton.	Value per ton.	
			$	
50	Nil.	73·60	73·60	50·11
51	Nil.	105·00	105.00	63·35
52	Nil.	30·08	30.08	20·64
53	Nil.	29·96	29.96	18·62

As may be seen from the above results the deposits are of high grade and could doubtless be worked at a profit even under present conditions of transportation and with hand methods of mining. Several hundred tons of ore could doubtless be extracted and hand-sorted for shipment, but as the veins are small, and unlikely to prove persistent in depth no large tonnage is to be expected. Such ore-shoots, however, rarely, if ever, occur singly. The conditions are such as to warrant further exploration work in the hope of encountering other bodies, and it seems probable that in order to secure results such work should be confined to the dyke rock. There is no reason for supposing that the veins already discovered are the largest and best in the immediate vicinity, as they really were discovered as the result of a canyon having formed at this place. Trenches laying bare the surface of the dyke are consequently quite likely to disclose similar bodies.

With regard to the district as a whole it may be said that the geological conditions indicate the probability of other mineral deposits. The district is one of intense igneous activity and such conditions are frequently favourable to the formation of ore deposits. The occurrence of galena float in large pieces in the canyon at points farther up than the known veins points to the existence of other ore-bodies which have not yet been located.

MERCURY DEPOSITS OF KAMLOOPS LAKE.

By Charles Camsell.

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GENERAL CHARACTER OF THE DEPOSITS.

Large quantities of mercury have been used during the war in the manufacture of munitions, for detonators and explosives, and, since the British empire is entirely dependent on foreign sources for supplies of this metal, it was considered advisable to

make an investigation of the deposits at Copper creek on the north side of Kamloops lake as a locality from which a supply might be obtained if other sources were cut off.

A small production was made from these deposits during the years of 1895, 1896, and 1897 and the statistical tables of the Geological Survey, Section of Mines, show that a total of 138 flasks of mercury were produced in those years, the value of which ranged from $33 to $36 per flask of 76½ pounds. Development work was continued on these deposits up to 1901, but no ore was treated in the furnace which had been erected by the Cinnabar Mining Company of British Columbia because of the low extraction that had been made in it during the earlier operations. Most of the important mineral claims having by this time been crown granted, development work ceased and practically nothing has been done since.

In his report on the area of the Kamloops Map sheet[1] Dawson refers to these deposits as giving evidence of becoming of some importance as development progressed and the mining that took place later to some extent confirmed his opinion.

It was with the object of reviving the industry at this locality, if the deposits should prove on examination to be worthy of exploitation, that a visit was made to the deposits about the middle of July: for it was highly desirable, in the interests of the country and the British Empire, that mining of these deposits should be carried on if it could be done profitably.

Since 1897 there has been no production of mercury from any deposits in Canada.

During the war Canadian imports fell off over 50 per cent, a decline which was partly due to transportation difficulties and governmental restrictions and partly to the decreased use of mercury in the extraction of gold from its ores. The removal of these restrictions and the return of normal transportation conditions will, no doubt, cause an increase in our imports and make the present time an opportune one for the development of those deposits of mercury that are capable of development in the face of European competition.

The mercury deposits of Kamloops lake occur at intervals along a belt 25 miles in length which extends from the west end of the lake northward to Criss creek and southward to Tunkwa lake. The principal deposits are situated in the valley of Copper creek, one group lying at the mouth of the creek overlooking Kamloops lake, and another group about 4 miles up the creek on the east side. Other deposits of less importance occur at Tunkwa lake, at the mouth of Threemile creek, and also in the valley of Criss creek.

The deposits are all of similar character. They occupy fissures which have no regular or uniform strike, and which traverse both the Nicola series and the Tertiary volcanic rocks. In many places they are closely associated with dykes of rhyolite or porphyry. The veins carry cinnabar, frequently associated with stibnite in a gangue of quartz, calcite, or dolomite, which weathers to a rusty outcrop. The deposits filled what were once open fissures, for a well-defined comb structure is frequently apparent. In some places the veins have a brecciated character and in others a banded structure. Specimens indicate that the calcite and quartz were introduced after the deposition of the cinnabar and stibnite, and also after the brecciation of the veins. The walls of the veins for a few inches on either side show alteration by the solutions which passed through them.

The deposits have probably been formed as after effects of late Tertiary volcanic activity and are due to the circulation of mercury bearing waters through fractured parts of the country rocks and the concentration of cinnabar in some of the veins. As in most other cinnabar districts of the world these deposits were probably formed near the surface and are not likely to extend to any great depth, and in the development of the deposits this should always be borne in mind.

No attempt was made to determine the grade of the deposits by sampling, but it is stated by G. F. Monkton[2] that in the first work of the British Columbia Cinnabar

[1] Geol. Surv., Can., vol. VII, p. 340B.

[2] "Cinnabar bearing rocks of B.C." Trans. Inst. Min. Eng., London, vol. XXVII, 1914, pp. 463-469.

Company in 1895 to 1896, 114 flasks of mercury were extracted in retorts from 150 tons of ore, which would make the grade of the ore treated 2·9 per cent. This, however, was picked, high grade ore. The low grade ore, as sampled by J. D. Kendall in 1896, yielded only 0·3 per cent of mercury. Other estimates of the grade of the ore range from 1·0 to 2·0 per cent.

CINNABAR MINING COMPANY OF BRITISH COLUMBIA.

The property of this company consists of a group of nine, crown granted, mineral claims, situated on the shore of Kamloops lake at the mouth of Copper creek. The group is favourably situated for transportation, for the main line of the Canadian Northern railway runs through the property and the station of Copper Creek is within half a mile of the outcrop of the deposits.

The deposits are situated 400 or 500 feet above the lake level on an open hillside, which is timbered higher up.

The country rocks are volcanic tuffs, breccias, and porphyrites belonging, probably, to Dawson's Nicola series. Bands of limestone are stated to be interbedded with the volcanic rocks. Owing to the massive character of the beds dips and strikes are difficult to determine. A heavy bed of conglomerate referable to the Coldwater series rests unconformably on the volcanic rocks and outcrops higher up the slope of the hill.

Cinnabar occurs in these deposits in a number of small veins, associated frequently with stibnite in a gangue of quartz, dolomite, and calcite. The outcrops of the veins are marked by bands of rusty weathering dolomite, which do not appear to run in any one direction, but have a general north and south trend. Owing to the drift covered nature of the hillside and the broken down character of all the underground workings it was impossible to determine the number of veins or, in most cases, their widths. It is stated on good authority, however, that there is a considerable number of veins with widths ranging from 2 inches to 2 feet.

To arrive at a fairly accurate estimate of the grade of the ore it would have been necessary to clean out the old workings and sample the veins, an undertaking requiring more time than was at our disposal. The results would also depend on the width of the ore sampled and how much of low grade wall rock was included. Sampling of these veins by the owners indicates that the grade of the ore ranges from 0·3 per cent to about 10 per cent. The average, however, would very likely be in the neighbourhood of 1·0 per cent.

Over $100,000 had been expended by the company on these claims, in assessment work, mining, and reduction of the ores. A retort plant was first built to treat the high grade ore and later this was replaced by a furnace for low grade ore, which, however, was never successfully operated.

The development work consists of open-cuts, adit tunnels, and shafts. A light railway carried the ore from the workings to the furnace. No work has been done for several years.

The total production from these deposits during the time the retort plant was in operation, namely 1895 to 1897, was 138 flasks, equivalent to 10,557 pounds of mercury. The failure of this industry is attributed to the heavy losses in the furnace which replaced the retort plant and not to the grade or character of the ore. With the greatly enhanced price of mercury and proper reduction works the deposits might be worked profitably at the present time.[1]

HARDIE MOUNTAIN MINES, LIMITED.

The claims of the Hardie Mountain Mines are situated 4 miles up Copper creek on the eastern slope of the valley. They consist of fourteen claims, all of which are crown granted. The bunk houses of the company are situated 1,000 feet above Kamloops lake and the workings extend from that point up to the top of the slope 800 feet higher up. The deposits are all situated near the top of the mountain. The country rocks consist of tuffs and breccias cut by dykes of porphyry and are mapped by Dawson as belonging to the Upper Volcanic group of Miocene age.

[1]Since this statement was written the price of quicksilver has fallen from $135 a flash to $90 and there is a probability of the price going lower still.

The deposits consist of dolomite veins traversing the tuffs and breccias and containing cinnabar as the mercury ore. The veins are usually only a few inches in width, and though the general character of the deposits is similar to that of the Cinnabar Mining Company the grade in general appears to be considerably lower.

Several thousand dollars were spent in the development of these deposits, but no actual mining was done nor any extraction of mercury made. On the top of the hill, where the veins outcrop, several pits were sunk; long open-cuts were made; and a few short tunnels run. With the idea of opening the deposits for mining on a fairly large scale, four crosscut tunnels were commenced at vertical intervals of about 200 feet down the side of the mountain, but none of them reached ore nor was the likelihood very great of their ever cutting any ore at the lower levels. These workings have been abandoned for several years.

OTHER DEPOSITS ABOUT KAMLOOPS LAKE.

The Independent group is situated near Sabiston flat, about 2 miles west of Copper creek. The veins are dolomitic in character and are situated in a pink porphyritic rock which traverses volcanic rocks of the Nicola series. These rocks show the effects of considerable disturbance and are much shattered and faulted and the lines of fracture run in all directions. The principal vein, on which a short tunnel has been run, is about 4 inches wide, and the quantity of cinnabar in it is not great. No work has been done on this group for several years, and no production has ever been made.

The Summit claim is situated near Tunkwa lake at the head of Threemile creek, on what is called the Summer range. The wagon road from Savona to Mamit lake runs by the outcrop of the deposit, which is about 14 miles from Savona. The country rock is a volcanic breccia, probably of Triassic age, which has been fractured and brecciated. Dolomitization has taken place along some of the fracture zones and this has been accompanied by mineralization by cinnabar and a little stibnite. Later fracturing has allowed the introduction of quartz into the veins. The deposit on which the development work has been done is a vein a few inches wide which appears to strike northeast and dips about 75 degrees to the southeast. A slight impregnation by cinnabar, of the wall rocks on either side for several inches, is occasionally noticeable.

The deposit is said to run about 1½ per cent mercury for a width of one foot. The development work consists of a shaft 15 feet in depth and a pit about 6 feet deep.

Float cinnabar was found some years ago in Criss creek and afterwards traced to deposits in place on the north side of the creek, about 4 miles from its mouth. At the time of our visit, these deposits could not be found and an examination of them could not be made. The rocks, however, are volcanic rocks of Triassic age, overlaid by agglomerates, tuffs, and conglomerates of Tertiary age. The former show the same bands of dolomitization as appear at the mouth of Copper creek and the cinnabar deposits are said to occur in these dolomite bands. Samples of high grade mercury stated to have come from Criss creek were shown us, which must have come from a vein at least 4 inches wide.

OTHER BRITISH COLUMBIA MERCURY LOCALITIES.

Native mercury has been reported as occurring in the silver ore of Silver peak near Hope.[1] It also occurs at Seehart channel, Barclay sound, on the west coast of Vancouver island, in minute globules scattered through a vein of cinnabar traversing a greenish felsitic rock.[2] Mercury has also been found in the gravels of Kicking Horse valley, near Field, but an examination made by J. A. Allan in 1913[3] failed to reveal the original source of the mercury, or whether or not it was likely to be present in commercial quantities.

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[1] Geol. Surv., Can., vol. V, pp. 65 and 66R.
[2] Geol. Surv., Can., vol. V, p. 65R.
[3] Geol. Surv., Can., Mem. 55, 1914, p. 235.

Besides the occurrences at Kamloops lake, cinnabar is reported by Dawson as having been obtained in washing the gold-bearing gravels of Fraser river at Boston bar.[1] It occurs in calcite veins in lower Kicking Horse canyon, east of Golden.[2] Specimens of rich cinnabar ore have also been obtained from outcrops of a vein on the Homathko river, which flows into the head of Bute inlet.

During the summer of 1918 specimens of cinnabar ore were submitted by J. B. McPhail of Lillooet, from a narrow vein which outcrops on the north side of the Chilcotin trail just south of the Taylor Creek divide at an elevation of about 6,300 feet above sea-level. The ore is also said to occur on the south slope of Cheakamus canyon near the line of the Pacific Great Eastern railway.

The most important occurrences of cinnabar, however, except those on Kamloops lake, are on Sechart channel on the west coast of Vancouver island. These were examined by V. Dolmage who gives the following description of the deposits:

"This deposit of mercury is situated about half a mile up a small creek which flows into Sechart channel about half a mile southeast of the whaling station.

The deposit was discovered many years ago and considerable development was done at various times, and by different owners. The best and most recent work was done by Mr. T. Golbey of Victoria, during the last two years; but unknown to him, the claims had been crown granted, and recently sold at a tax sale, to Mansfield and Gardner the present owners. At the time of visit no work was being done on the property.

The development work consists of five or six short tunnels in the banks of the creek, and a shaft of considerable depth from which a large dump of fairly good ore was taken. Some diamond drilling has also been done, but with what results is not known. The deposit lies in a highly sheared zone at the contact of a granodiorite or granite with an older limestone and, probably, other sedimentaries, such as argillite. The shear planes strike north 22 degrees east and have a vertical dip. Much of the cinnabar, which is the essential ore mineral, is distributed in thin sheets along the shear planes, though much of it is also disseminated through the unbroken rock.

The granodiorite in its fresh state, as seen some distance from the contact, has the texture of a medium-grained plutonic rock, and is light grey in colour. Near the contact this rock becomes increasingly basic, in some places it has the composition of a hornblende gabbro, and in others it becomes almost a hornblendite. It has also suffered an intense metasomatic as well as dynamic alteration so that its original composition is often completely obscured.

Kaolin is the most important secondary mineral, but quartz, serpentine, calcite, and chlorite are also exceedingly abundant.

The limestones are altered to cherts and serpentines and also intensely sheared.

The cinnabar is best developed in the cherty limestone where it is seen replacing quartz and calcite.

Only a small amount of pyrite is present, and though some other metallic sulphides are known to be present they have not been determined.

Considerable metallic mercury is found in the ore on the old dump, but none was observed in freshly collected specimens.

It is impossible to give any estimate of the size of the ore-body as many of the workings showed no ore whatever and others were inaccessible.

A dump consisting of several hundred tons, most of which, presumably, came from a shaft, appears, where it can be examined, to contain 2 or more per cent of cinnabar.

The shear zone is from 20 to 50 feet wide, and much of it has not been prospected.

The writer's opinion, formed from an examination necessarily short and made in a drenching rain, is that with properly conducted prospecting an ore-body of economic value might possibly be developed."

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[1]Geol. Surv., Can., vol. II, p. 9T.

[2]McConnell, R. G., Geol. Surv., Can., vol. III, p. 66R.

FOREIGN DEPOSITS.

The United States and Mexico are the only producers of mercury in America. Over 70 per cent of the mercury produced in the United States is obtained from Californian deposits. The remainder is produced in Texas and Nevada, and a small quantity comes from Oregon and Washington. These deposits are veins, stockworks, fractured zones or chambered breccia veins occurring in rocks of any composition, but mainly of Tertiary or Quaternary age.

The deposits are generally small and decrease in size or give out in depth. They are as a rule confined to the upper vein zone and many of them do not go more than 400 feet below the surface. They have been formed in late geological times and are closely related to volcanic activity, many of them being associated with hot springs.

The average grade of the ore now being mined in California is about 0·4 per cent of mercury, and the cost of producing is in the neighbourhood of $1 per pound. The Texas deposits run about 4·00 per cent.

European supplies are obtained from Spain, Austria, and Italy.

The Almaden mines in Spain which are the largest mercury mines in the world, yield mercury at a cost of $16 per flask from cinnabar ore averaging 11 per cent mercury.

The Italian deposits average about 1·00 per cent and the Austrian about 0·85 per cent. Other deposits occur in Germany, Russia, Asia Minor, China, Serbia, Australia, and New Zealand.

USES.

Mercury is used in medicine, electrical apparatus, batteries, vermilion, amalgamating of gold and silver, measuring instruments, paints, cosmetics, floating lights, in light houses, and in power plants The requirements of Canadian users are about 200,000 pounds annually.

BORING OPERATIONS FOR OIL IN THE VICINITY OF VANCOUVER, B.C.

By Charles Camsell.

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INTRODUCTION.

Much local interest has recently been taken in the possible occurrence of oil in the neighbourhood of Vancouver and three holes are being drilled to test the ground. The possibility of oil in the sedimentary rocks underlying the lower Fraser River district has excited the interest of local mining men for several years past, owing to the presence of seepages of both oil and gas at a number of points, and a few attempts have been made to raise money for prospecting with a drill.

Such seepages of oil or gas are said to occur at Point Grey, West Vancouver, Pitt lake, and other points farther inland, but the origin of those seepages and whether or not they are connected with pools of commercial importance has not, as yet, been demonstrated.

GEOLOGY.

The lower Fraser River district, from Agassiz to the coast, is in the main low and fairly level, with elevations ranging from sea-level to about 500 feet above it. Here and there isolated hills rise above the general level, reaching altitudes of about 1,000 feet above the sea. Sumas and Chilliwack mountains and the hills immediately east of Vancouver are examples of these higher eminences.

All along the northern side of this low country the granitic hills of the Coast mountains rise steeply to heights of 4,000 or 5,000 feet, and on the east are the high mountains of the Cascade range, which are built up of igneous and older sedimentary rocks. Southward the low country extends into the state of Washington. The whole of the low lying country on both sides of Fraser river is presumed to be underlain by sedimentary rocks of Eocene age, though at Sumas mountain Cretaceous rocks project through them.

These Eocene rocks, which are made up of conglomerates, sandstones, and some shale, are the possible oil-bearing strata and the rocks from which the seepages of oil are believed to have arisen. They contain a variety of plant remains and a few small coal seams, and are in certain places intruded by dykes of porphyrite or andesite.

Few natural outcrops of the Eocene rocks are exposed except in the cliffs and railway cuttings along the south side of Burrard inlet and in the sea cliffs on the shores of English bay. Elsewhere they are covered by a heavy mantle of Glacial and post-Glacial sands, gravel, and clay, which varies from a few feet to several hundred feet in thickness and so obscures the beds that their structure is difficult to work out. Dips, however, of 10 to 15 degrees to the southward, may be measured at the natural exposures. The total thickness of these beds in the Fraser River district has been estimated at 3,000 feet. Weaver[1] gives them a thickness of 10,000 or 12,000 feet of sediments and intercalated basalts in the state of Washington, into which they extend and where they have been thrown into a series of anticlines and synclines with a general north and south trend.

The topographic features of the country about Vancouver and south of the Fraser river are such as to suggest to the layman that the underlying solid rocks have been folded into a series of anticlines and synclines, creating structural conditions favourable for the accumulation of oil. There is, however, little evidence to indicate that the ridges and hills of this district are expressive of the attitude of the underlying bedrock, for they are frequently either accumulations of Glacial or Recent material deposited in the form of hills, or else they represent remnants of a higher land surface that has been almost completely eroded away. There is, therefore, very little structural evidence, in the district itself, on which to base conclusions as to the presence or absence of commercial bodies of oil in these rocks, though it is only to be expected that the anticlinal structure which obtains in these beds south of the International Boundary line will be found in the beds of the Fraser River district.

As far as the lithology of the beds is concerned there are great thicknesses of porous sandstones capable of acting as reservoirs for oil, but so far as is yet known there are relatively few beds sufficiently thick or impervious to constitute a cover capable of preventing the escape of oil to the surface.

A thin bed of sandy shale outcrops on the south side of Burrard inlet, east of Hastings, and other thin beds have been encountered in the boring near Burnaby lake.

Admitting that two conditions necessary to a commercial oil field have been fulfilled in this district, namely, lithological composition of the beds, and a favourable structure which would allow oil or gas to flow and accumulate in pools, there remains the question of the original source of the oil.

In order that oil or gas may occur in any rocks it is considered necessary that organic material must have been present at the time the rocks were being laid down and that favourable conditions for the embedding of such organic material should have existed. It is generally considered, also, that marine animal life was necessary for the formation of deposits of oil.

The Eocene beds of the lower Fraser River district are mainly sandstones and conglomerates laid down along the shores of an estuary into which streams were discharging their load of sediment. The beds accumulated so rapidly that under ordinary conditions the proportion of sediment to animal material would have been large and marine animal life itself not particularly abundant.

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[1] Wash. Geol. Surv., Bull No. 13, 1916.

A certain quantity of vegetable material was present, however, as shown by the occurrence of fossil plants and small coal seams, but the information obtained from natural exposures and drill cores does not as yet indicate that the Eocene beds contain sufficient organic material to have produced commercial deposits of oil.

This is the conclusion arrived at by the geologists of the state of Washington, where the Eocene beds are better exposed and where they have been more carefully studied than in the province of British Columbia.[1]

The possibility of older petroleum-bearing rocks underlying the Eocene and furnishing a supply of oil to the Eocene must, however, be considered.

At Sumas mountain the Eocene rests on volcanic rocks and on the north side of Fraser river on granitic rocks, neither of which is a possible source of oil. Triassic and older rocks form the mountains east of Chilliwack and may extend under some of the region covered by the Eocene rocks, though no evidence of such extension is available.

The Triassic rocks which are grouped together by R. A. Daly under the name "Cultus" formation are described by him as being made up dominantly of "dark grey to blackish argillites often bituminous in moderate degree."[2] They are several hundreds and possibly thousands of feet in thickness and contain marine fossils. This formation is a remote but possible source of oil in the Eocene rocks and of the seepages that occur here and there throughout the district.

It is necessary to mention another possible source of the oil of the seepages, which has been referred to by J. B. Tyrrell.[3] Tyrrell attributes the origin of the oil to distillation from coal seams that have been intruded by dykes of igneous rocks. If this theory of origin is correct the seepages have no particular significance and a commercial oil field is not to be expected.

The evidence bearing on the original source of the oil seepages and whether or not they denote commercial bodies of oil underground is so scanty that definite opinions cannot be expressed regarding the occurrence of an oil field in this district. In locating the sites of drill holes, however, operators should not neglect to use all the geological data available and especially those bearing on the structure of the rocks, for by these methods much territory can be eliminated as not likely to contain oil deposits and operations may be confined to those areas that are favourable. It is regrettable that these methods have not been used in every case in selecting the sites for the drilling operations that are now in progress, for they are the only methods that have been proved by experience to be effective in the location of commercial fields.

DRILLING OPERATIONS.

The first deep drilling operations in the lower Fraser River district were conducted about thirty years ago by the Canadian Pacific Railway Company with the hope of finding workable seams of coal. Holes were drilled at that time at Kitsilano and at Port Haney, but no logs of these holes are now available. Gas is reported to have been struck in the Port Haney hole at a depth of 600 feet, and as a result of this a Vancouver group of men began drilling in 1914 near the site of the old Canadian Pacific Railway well with the hope of obtaining gas or oil in commercial quantities. The drill attained a depth of 1,250 feet and the hole was then abandoned. J. D. Galloway[4] reports that the drill was in sandstones and shales the whole way.

The Pitt Meadows well, which was begun in December, 1913, by the Pitt Meadows Oil Wells, Ltd., is situated in sec. 13, tp. 40, range 5, W. 7th mer. Broad, flat meadows, almost completely flooded at high tide, extend from Fraser river up the valley of Pitt river to Pitt lake, the upper part of the valley lying between the granitic hills of the Coast mountains, and having "islands" of these rocks rising up through it. The site of the well in these meadows is just inside the outer line of the mountains. The first

[1] Wash. Geol. Surv., Bull. No. 13, p. 268.
[2] Geol. Surv., Can. Mem. 38, p. 516.
[3] Trans. Am. Inst. Min. Eng., vol. 52, 1915, p. 248.
[4] Ann. Rept. of Minister of Mines, B.C., 1914, p. 392K.

hole put down at this point reached a depth of about 1,200 feet and owing to some difficulties was then abandoned. The present hole was started in December, 1913, and on January 1, 1919, was down 1,990 feet, over 1,000 feet being in drift before the solid bedrock was reached. A small showing of oil is said to have been obtained at 1,964 feet, from a thin bed of sandstone. Owing to the loss of some tools in the hole only about 100 feet in depth have been made in the last three years. The site of the hole was located by a magnetically controlled instrument which is supposed to indicate the presence of oil beneath the surface.

A company known as the Empire Oil and Natural Gas Company is sinking a well in sec. 27, tp. 10, range 4, W. 7th mer., about a mile south of Otter station on the Great Northern railway. Drilling with a Keystone drill has been in progress since April, 1918. The first hole at this site was put down to a depth of 350 feet and then abandoned without reaching bedrock. A second hole put down beside the first reached a depth of 140 feet and was also abandoned. A third hole at the same site had reached the depth of 65 feet on January 6, 1919. All the holes passed through a top stratum of coarse gravel and were continued in soft sands. None of the holes reached solid rock.

A diamond drill hole is being put down by the Spartan Oil Company in the municipality of Burnaby about a mile north of the west end of Burnaby lake, on lot 130. One of the most important seepages of oil occurs at this point alongside the tracks of the Great Northern railway. Drilling was begun on August 15, 1918, and was still in progress on January 15, 1919, when a depth of 1,060 feet had been attained. The surface drift at this point was found to be 110 feet in depth and the strata encountered were sandstones, conglomerates, and some shale. Small showings of gas and oil have been obtained from sand streaks in the conglomerate at several points below 640 feet. A contract has been let to sink the hole to a depth of 2,000 feet.

COPPER MOUNTAIN, GUN CREEK.

By Charles Camsell.

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Map 1741. Sketch map of Cooper mountain, Gun creek, B.C.	26B

LOCATION AND TOPOGRAPHY.

Copper mountain is situated at the head of Gun creek, a tributary of Bridge river, in Lillooet mining division. The station of Shalalth, on the Pacific Great Eastern railway, is the nearest railway point to the locality, and the route from it follows the Bridge River wagon road across Mission mountain as far as Pearson ponds, a distance of about 30 miles. From this point the present route is by the old Chilcotin trail which runs over two high mountain summits past the head of Eldorado creek and down into the valley of Gun creek near Spruce lake. These summits are respectively 6,700 and 7,300 feet in elevation above the sea, and on account of their altitude can only be crossed in the summer months.

A new pack trail is now being built from Bridge river, which will follow the valley of Gun creek all the way to Green lake at the mouth of Copper creek, a distance of about 30 miles. This trail, if built along the bottom of the valley, could have a grade of not more than 2½ per cent for the whole distance to Green lake.

Green lake lies in the valley of Gun creek at an elevation of about 5,400 feet above the sea. The trail from this point turns southward up the steep slope of Copper Creek valley and rises rapidly for a mile and a half to the camp which is situated in a cirque-like basin at an elevation of 6,500 feet.

The total distance of the camp from the railway is about 65 miles, half of which is covered by wagon road and the other half by pack trail.

Unless some easier route can be discovered a railway line to Copper mountain would have to follow the valley of Bridge river from its mouth to Gun creek to avoid the climb of 3,000 feet that the wagon road makes over the top of Mission mountain between Shalalth and Bridge river. From the mouth of Gun creek the route would follow the valley of Gun creek. This would mean a railway of about 80 miles in length in order to reach and develop the copper deposits. Access to the district from the west is impossible owing to the ruggedness of the mountain ranges on that side.

Copper Mountain district lies in the Coast mountains, but on their eastern flank where the rugged, snow covered, granitic ranges pass into a lower and more subdued belt of mountains which is transitional eastward into the Interior Plateau region. Geologically it is situated on the eastern edge of the Coast granodiorite batholith. The accompanying sketch map indicates the topography of the district immediately about Copper mountain.

The bare, basin-like valley of Copper creek lies between two short ranges of mountains which at the head of the creek curve inward and meet in a group of peaks whose summits are about 8,500 feet in altitude and scarcely protrude through the encircling snowfields. The creek is fed from banks of snow lying on the sides of the basin, many of which are permanent fields. Copper mountain is one of the peaks of the range on the eastern side of the basin and has an altitude of 8,000 feet. The range on the western side of the valley is somewhat lower. The valley bottom of Copper creek above the 6,600-foot contour-line and the slopes of the basin are all bare of timber, so that except where covered by talus and other drift the bedrock is well exposed. The slopes of the basin are very steep and in places unscalable, but their lower parts are covered by angular blocks of talus broken off from the cliffs higher up.

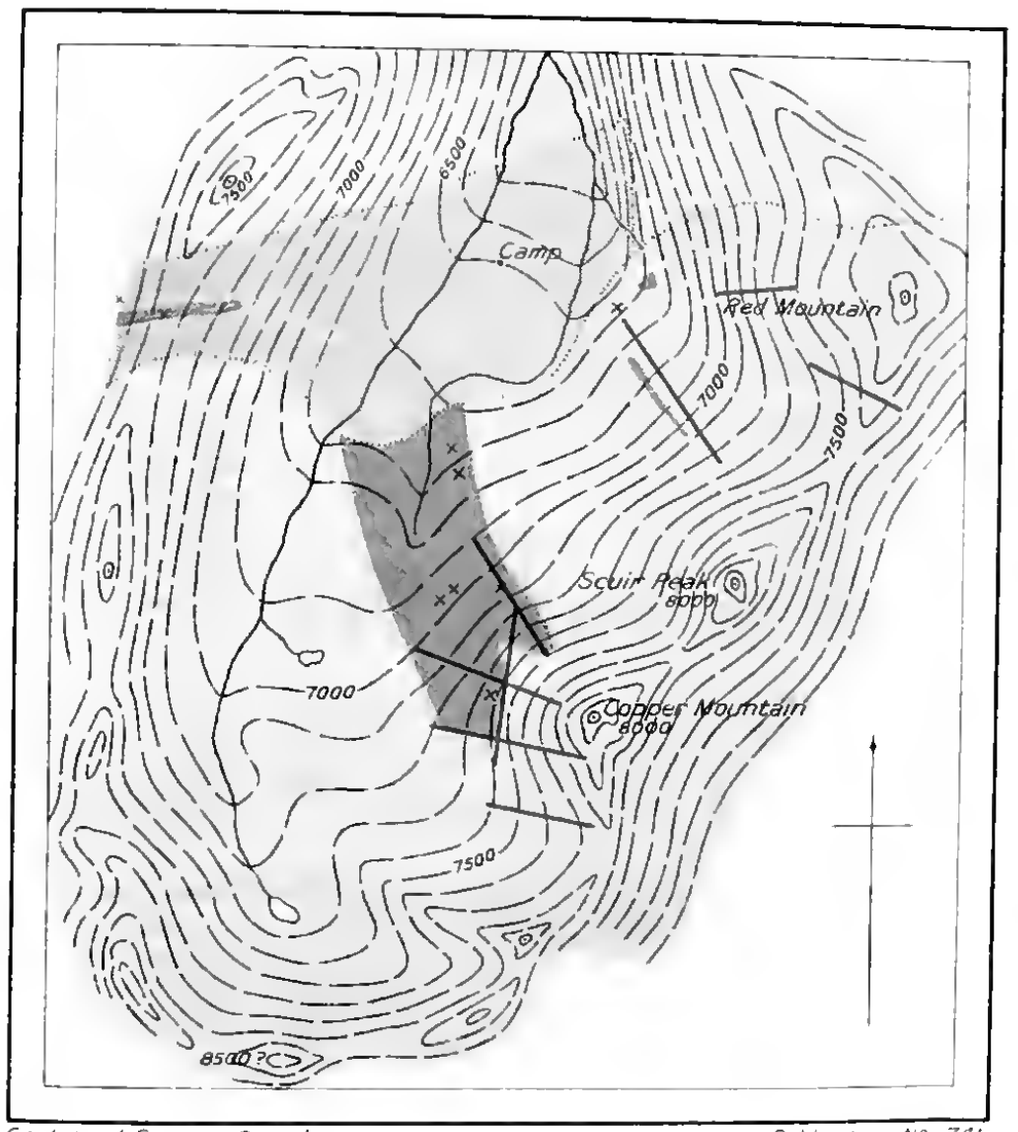
GEOLOGY.

The oldest rocks of the district are a group of stratified rocks embracing porphyries and porphyrites which are believed to be of the same age as beds of sandstones and conglomerates exposed in the valley of Gun creek. They have all been metamorphosed by both regional and contact action and dip at high angles with a strike about east and west. A coarse-grained granodiorite, part of the Coast batholith, is intrusive into the stratified rocks and is itself intruded by a later diorite porphyry. The stratified rocks occupy the northern part of the area, the granodiorite covers the central and southern part, and the diorite porphyry forms a belt 1,000 feet or so in width between the two other formations. Besides these major formations there are a large number of dykes which cut the stratified rocks and the granodiorite, but do not appear to be intrusive into the diorite porphyry.

The granodiorite, which is the ore-bearing formation, is a massive, coarse-grained rock made of feldspars, both plagioclase and orthoclase, quartz, hornblende, and biotite. In certain wide zones it is very much fractured and even brecciated, and in places has a nodular structure with circular nodules ranging from a foot to several feet in diameter. It carries inclusions of the stratified rocks.

The diorite porphyry is a medium-grained, tough, grey rock with slightly porphyritic texture. It is quite fresh and shows no evidence of dynamic metamorphism. It carrries inclusions of the granodiorite and sends off dykes into it. At its contact with the granodiorite it becomes lighter in colour and more acid in composition and its apophyses show evidence of primary sulphide mineralization.

The porphyry dykes which cut the stratified rocks and the granodiorite are mainly granodiorite porphyry, syenite porphyry, and quartz porphyry. The majority



Legend

- Diorite porphyry (Post-granodiorite)
- Granodiorite (Post-Lower Cretaceous)
- Porphyries, tuffs, conglomerate, sandstone (Lower Cretaceous)
- Porphyry dykes
- Mineralized zone of iron and copper sulphides
- Open-cuts

Geological Survey, Canada — Publication N° 1741

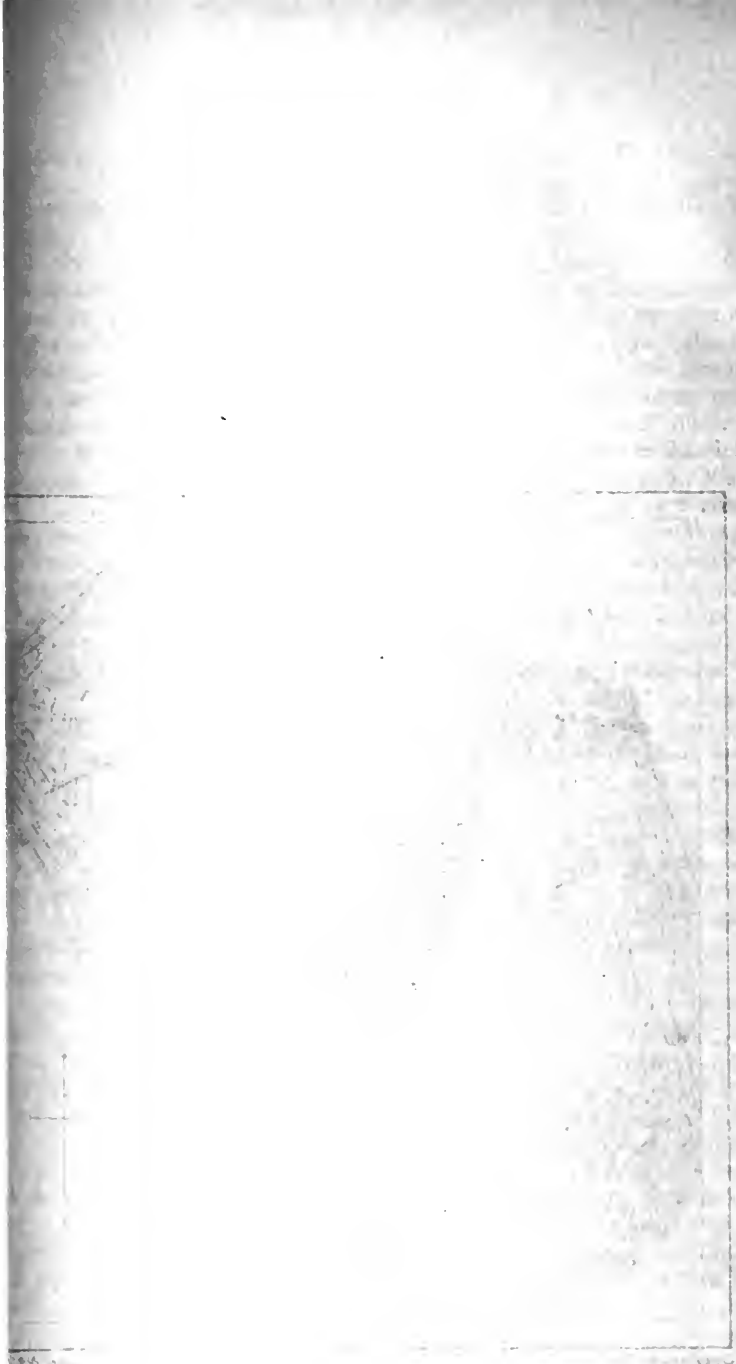
Sketch map of **Copper mountain**, Gun creek, Lillooet mining division, British Columbia.

Scale of feet

1000 0 1000 2000

Contour interval, 100 feet

To accompany Summary Report by Charles Camsell, 1918.



of them strike in a northwesterly direction, but there is a wide variation in the direction of many others and some have a pronounced dip.

MINERAL DEPOSITS.

The principal deposits occur in the granodiorite and are situated on the slope of Copper mountain, running down in Copper creek. They occur in zones of fracture which extend up the mountain side for several hundred feet. The principal fracture zone occurs on Copper mountain and can be traced diagonally up the mountain side from the upper border of talus for a distance of 1,000 feet or more, with a width of 500 or 600 feet. In this zone the granodiorite is fractured and frequently brecciated, and in places has developed a peculiar nodular structure which covers several hundred square feet in area. The nodules of granodiorite in this area are spherical in outline with diameters ranging from a foot to several feet.

The fracture lines throughout this zone are filled with narrow seams of quartz and calcite carrying pyrite and chalcopyrite and sometimes magnetite. The same minerals surround the nodules of granodiorite where the nodular structure has been developed. In some places the fractures have not been entirely filled and open vugs are left which are lined with pyrite, chalcopyrite, and magnetite. The unbroken parts of the granodiorite show some evidence of primary mineralization by iron sulphide which occurs in well formed crystals.

The greatest amount of sulphide mineralization has taken place in areas of this fractured zone, where the fracturing has been most intense and where the nodular structure is best developed.

The lower contact of the fractured zone is covered by talus from the mountain side, but the upper limit is fairly well exposed, with zones of fracture extending up from the main zone for several feet.

The whole zone is traversed by numerous dykes of porphyry which are not fractured and consequently not mineralized.

Other zones of fracture showing a similar mineralization by iron and copper sulphides outcrop on the slopes of the mountain both to the north and the south of the main zone.

The origin of the deposits may probably be attributed to the diorite porphyry which on intrusion into the granodiorite fractured and brecciated it along certain zones. These zones then became channels along which the quartz solutions travelled, bearing with them some iron and copper which were deposited as the sulphides of these metals.

None of the fractured zones have well-defined limits and the mineralization appears to die out gradually on all sides into unfractured and unmineralized country rock. Sulphide mineralization, too, is not uniform throughout the length and breadth of the various zones. This, and the great extent of the areas of mineralization make it difficult to properly sample the deposits and arrive at any conclusions as to their copper contents. On this account and because of the short time spent on the deposits no sampling was attempted.

A sample, taken by R. W. Thomson, Provincial Resident Engineer of the Central district, across 6 feet of one of the mineralized areas, gave on assay: gold, trace; silver, trace; copper, 0.5 per cent. Average samples by the owners across widths of 20 to 100 feet of the surface rock gave results as follows: gold, trace to 40 cents; silver, 20 to 95 cents; copper, 0.15 to 1.6 per cent. Other samples indicate that the silver is an important constituent and might determine whether or not the whole deposit could be worked at a profit. Picked samples have yielded as much as $238 in all values.

The development work on the deposits consists of a number of small open-cuts on the slope of the mountain side, none of which goes more than a few feet into the solid rock.

The commercial value of these deposits as a source of copper has yet to be determined, and can only be determined by a great deal of development work. This must necessarily be an expensive undertaking owing to the distance at which the deposits are situated from the railway and the lack of a good road over which to transport machinery and supplies. The nature of the deposits and the large area over which sulphide mineralization extends would suggest the possibility that a large, low grade copper deposit might be developed which could stand the heavy expenses that must be incurred before the stage of actual production is reached.

In connexion with the development of the Copper Mountain deposits it should be borne in mind that owing to the geological conditions of the district, other deposits of metallic ores may occur in the neighbourhood. The deposits are situated on the eastern border of the great Coast range granodiorite batholith where this batholith is in contact with stratified rocks of both sedimentary and volcanic origin, and experience has already shown that it is under such geological conditions that a great many of the deposits of metallic ores of the North American continent occur. Other deposits of gold and copper in quartz veins have been staked to the north of Copper mountain, and it is the writer's opinion that the district about Copper mountain and to the north, generally, is a good field for prospecting.

The development of any of the deposits, however, will depend upon the building of a railway into the district, and each new discovery of mineral deposits increases the possibility of this being done.

PLATINUM INVESTIGATIONS IN BRITISH COLUMBIA.

By Charles Camsell.

A considerable part of the summer of 1918 was devoted to investigations of platinum deposits at different points throughout the province, in response to a request for such investigations by the British Ministry of Munitions and the Canadian Munitions Resources Commission, a new source of supply being required for war purposes to make up for the lack of production in the European fields.

The Tulameen district had been, in the past, the largest producer of platinum on the North American continent and to meet the urgent demands of the British government this seemed to be the most likely field from which an extra supply could be obtained.

In connexion with these investigation a short trip was made on June 18 into the Tulameen district to meet Eugene Poitevin, who was making a study of the geological conditions under which platinum occurs in that locality and comparing them with those obtaining in the Ural districts of Russia, from which the greatest part of the world supply of platinum has been derived.

On July 22, Mr. Poitevin and the writer visited Nelson, and sampled deposits on Rover creek, which were stated by the owners to carry considerable amounts of platinum. With the assistance of Mr. A. G. Langley, Provincial District Engineer, two localities were sampled on Rover creek, and the samples shipped to Ottawa for analysis. At the first locality, situated in the bed of Rover creek, at an elevation of 1,900 feet above the sea, a tunnel, 31 feet in length, had been driven on a lead 5 feet in width. The country rocks, which are exposed in a bluff 30 feet high, are altered limestones, lime silicates, hornfels, and porphyrites, dipping about 30 degrees to the south and striking north 60 degrees east. The lead is in an altered limestone mineralized by pyrrhotite and traversed by small stringers of quartz, which had been introduced along with the pyrrhotite as a result, probably, of the intrusion of the Nelson granite batholith.

The second locality, a short distance higher up the creek, is a rusty, stained, outcrop of similar altered rocks somewhat schistose in character, but showing less mineralization by pyrrhotite and quartz. At these localities assays made by a Philadelphia chemist are said by the owners to have given as much as 2½ ounces of platinum to the ton, and considerable gold.

Duplicate sets of samples were taken for analysis, one sample to be assayed in the laboratory of the Department of Mines, another sample to be assayed by Hand of Philadelphia, who claimed to have obtained high platinum values from samples previously submitted to him from this locality, and a third sample to be used as a check in case of disagreement in the results obtained from the first two samples.

Early in August, Mr. G. C. Mackenzie, Secretary of the Munitions Resources Commission, arrived in British Columbia from Ottawa, carrying instructions from the Commission to investigate the platinum possibilities of the province, and if possible obtain a supply of platinum to meet the urgent requirements of the British Ministry of Munitions.

In connexion with this investigation a visit was made with Mr. Mackenzie, commencing August 6, to the Tulameen and Similkameen districts, where it was considered this emergency supply might be obtained.

After looking over parts of the Tulameen and Similkameen rivers and Granite creek, and making rough preliminary tests of the gravels of these streams, a part of Tulameen river about the mouth of Slate creek was selected as the most favourable locality in which to work and, in September, Mr. Mackenzie put two drilling crews to work with one "Empire" drill and one "Keystone" drill, to thoroughly test the gravels for platinum, preliminary to carrying out dredging operations.

Visits were again made to the Tulameen district at later dates to consult with Mr. Mackenzie regarding the progress of the work.

Considerably more activity was displayed this year in the mining of the platinum-bearing gravels of Tulameen river than for many years previously, and the total production has been in the neighbourhood of 40 ounces.

The principal operators were Charles Thompson, J. J. Marks, J. Thomson, C. Swanson, and Church and Hawk, all of whom worked on Tulameen river between Bear creek and Eagle creek.

Thompson, Marks, Thomson, and Swanson were all working an old high run of gravel, about 8 or 10 feet thick, lying in some places on one side of the river and in some places on the other, at an elevation of 30 to 45 feet above the river. This gravel deposit rests on a bedrock of tough cement and is made up of pebbles and boulders of peridotite, pyroxenite, chromite, granite, and other rocks. No pay is found in the bedrock cement, but the gravel above it is said to carry good values in platinum, though, owing to the lack of water, it is very difficult to work and, late in the season, has to be carried down to the river for washing.

Church and Hawk endeavoured to mine a deep hole on Tulameen river, immediately above the mouth of Bear creek, at the entrance of the canyon. This hole is about 300 feet long and was known to have about 18 feet of water in it at the ordinary summer stage.

It was assumed that, owing to its depth and the difficulty of carrying the water of the river over the hole, it had not previously been mined by the old placer miners.

Work was commenced in July after the water had run off. A dam was constructed and a flume built to carry all the water of the river around the hole. Removal of the gravel in the hole was then begun, but, before bedrock was reached, and after the gravel began to show evidence of carrying both gold and platinum, a sudden freshet caused such a rapid rise of the river that the flume burst and the water overflowed the dam and filled up the hole with as much gravel as had been taken out. The delay occasioned by this flood was so great that winter came on and the water began to freeze before repairs were completed. As a result no actual washing of the gravels could be carried on, and consequently there was practically no recovery from a locality where the operators had good reason to expect it.

At the end of October, while on a trip to Jervis inlet in connexion with geological field work, a visit was paid to Potato creek, near the head of the inlet, where platinum was said to occur with gold in the gravels of the creek. Tests were run and samples taken by Mr. Thomlinson of the Munitions Resources Commission, and on analysis of the samples a report is to be presented to the Commission by him.

In November a trip was made to Shuttleworth creek, which enters Okanagan valley at Okanagan falls, where the geology suggests the possibility of platinum occurring in the gravels. The rocks are Pre-Cambrian gneisses associated with bodies of amphibolite and serpentine.

J. Hislop and G. Maynard have done some prospecting of the gravels of the creek and have obtained some evidence of the presence of platinum, but not as yet in commercial quantities.

It has been known for several years that platinum occurs in the gravels of Fraser river in association with placer gold. Traces have been obtained in the course of dredging operations at Hope. Black sand concentrates, obtained by R. D. Mclellan, of the Dominion Assay office, from the mouth of a small stream opposite Saddle Rock station, in Fraser canyon, yielded from 0·23 to 0·64 ounce of platinum to the ton.

About three-quarters of an ounce of crude placer platinum was obtained by J. Russell, of Lillooet, by cleaning up the tables of an abandoned dredge which some years ago was in operation a few miles below that point. Considerable platinum occurs with the gold in the gravels of Quesnel river, and a new locality was discovered this year on Government creek, which enters Fraser river 40 miles below Prince George. All of these occurrences make it possible that at some future time, when dredging operations are carried on for the recovery of gold on Fraser river or its tributaries, platinum may also be obtained as a subsidiary product.

Considerable interest was shown in prospecting for placer as well as lode platinum throughout the province as a result of the publicity given to the Government's requirements, the establishment of a local market in the Dominion Assay office at Vancouver, and the free assaying of platinum ores in that office. The full effects of this campaign have not yet been realized owing to the late date at which it was started, but there should be a noticeable increase in platinum production next year as a result of it.

PLATINUM SITUATION IN CANADA.

J. J. O'Neill during the past year commenced an investigation and study of the platinum situation in Canada in general, in relation to actual occurrences of platinum and to facilities for disposing of any platinum ores that might be produced. In the course of this investigation Mr. O'Neill visited a number of localities in British Columbia at which platinum has been reported to occur. A preliminary account of the information obtained is contained in Part G of the Summary Report for 1918.

QUATSINO SOUND AND CERTAIN MINERAL DEPOSITS OF THE WEST COAST OF VANCOUVER ISLAND, B.C.

By V. Dolmage.

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INTRODUCTION.

The field season of 1918 was spent in making a detailed examination of the shores of Quatsino sound and the adjacent coast, investigating the mineral deposits of that locality, and visiting as many of the known mineral localities on the west coast of Vancouver island as could be conveniently reached.

The writer was ably assisted by M. E. Hurst. The work was facilitated and rendered much more pleasant by the many favours and kindly attitude of the inhabitants of the places visited. Especial thanks are due to Mr. Clancy of the Old Sport mine, to Mr. Melin, geologist for the Coast Copper Company, and to Mr. Brewer of the British Columbia Department of Mines.

The only important work previously done in the district is that of G. M. Dawson, described in a report published by the Geological Survey in 1887. The work consisted of a geological reconnaissance of the east coast of Vancouver island and the west coast as far south as and including Quatsino sound. The object of last season's work was to commence a more detailed geological survey of the west coast of the island, special attention being paid to the mineralized areas. The work was confined to the shoreline because there were no topographic maps of the country which would serve as a base for the geological mapping, whereas the marine charts prepared by the admiralty provide an excellent base for shore work; and because work done along lines of easy communication is of much greater immediate value than work done in regions still inaccessible.

QUATSINO SOUND DISTRICT.

General Features.

Quatsino sound is the most northerly of the great ramifying inlets on the west coast of Vancouver island, which penetrate the interior of the island for many miles and in two instances come within a short distance of dividing it. The main channel of Quatsino sound extends in a northeasterly direction, almost at right angles to the coast, for about 20 miles and has an average width of about 1 mile. At its head it fingers into three large arms: Rupert arm extending to the east for about 10 miles; the Southeast arm extending about 13 miles in a direction south 35 degrees east; and the West arm extending north 70 degrees west for about 20 miles. These arms, considering their length, are all narrow, but have deep water, and are navigable for large ocean steamers throughout. The shores of the sound are sparsely settled by ranchers, most of whom are clustered in the vicinity of Quatsino village, at the head of the main channel of the sound. The village has a post-office and telegraph office. A large village has sprung up around the pulp mill of the Whalen Pulp and Paper Company, near the head of the Southeast arm. The main means of communication is by the *S.S. Maquinna* which plies between Victoria and Quatsino every ten days. Mail is also received weekly at Quatsino by courier, from Port Hardy on the east coast of the island.

The climate of the district is comparatively mild throughout the year, and hard frosts are rare, though considerable snow falls during the winter. The rainfall is excessive, somewhat over 100 inches falling annually, but, in spite of this, the summers are quite dry and very pleasant. The vegetation is luxuriant to an extreme and the forests skirting the shore are almost impenetrable. Where the ranchers have succeeded in clearing patches of ground in the forest, farming and gardening have proved fairly successful and hardy fruits thrive.

The country is very mountainous and except in the vicinity of Rupert arm, where Cretaceous sandstone and shale are well developed, steep mountains rise abruptly from the water's edge to elevations of 2,000 feet or more. The mountain ranges have a northwest trend, about parallel to the West and Southeast arms of the sound, this also being the direction of the main structure of the island. The largest rivers are those flowing into the heads of the several arms. They occupy structural valleys, of which the arms of the sound are merely submarine extensions deepened by glaciation. Similar valleys which have not been glacially deepened to sea-level lie on each side of and parallel to the Southeast arm. The one to the northeast is occupied by a series of large lakes draining into Rupert arm by Marble creek, and the one on the southwest is drained by a large river, named on some maps the Ingersoll.

General Geology.

The following table of formations summarizes the geology of the region:

Era.	Period.	Formation.	Lithological characters.
Quaternary.	Recent		Unconsolidated sands, gravel and clays, usually stratified.
	Pleistocene		Till and roughly stratified sands.
Tertiary.			Diabase dykes, cutting the Cretaceous.
Mesozoic.	Cretaceous		Sandstones, shales, and conglomerates with some coal.
	Jurassic		Intrusive diorites, quartz diorites, and granodiorites.
	Jurassic and Triassic.	Vancouver group	Andesites, tuffs, and basalts, interbedded with limestones.

The Vancouver group as defined by Dawson is very extensively developed in this district, and its members form the main country rock of all the northern end of Vancouver island. Of the total thickness, which is probably not less than 10,000 feet, by far the greatest part consists of volcanic rocks, mainly andesites and tuffs. Interbedded with these are extensive beds of limestone varying in thickness from a few feet to 2,000 feet.

The volcanic rocks vary in composition from rhyolite to basalt; but andesites are the most abundant, and all the large flows are of this composition. They are characterized by a large amount of alteration, the common secondary minerals being chlorite, calcite, epidote, and sericite. The ferromagnesian minerals are almost invariably replaced by chlorite and iron oxide, usually hematite. Tuffs are very common in the series and are usually very fine, well banded, and dark in colour, causing them to be frequently mistaken for argillites. They are usually fossiliferous.

The limestone occurs chiefly in one large bed, which outcrops continuously along the east shore of the Southeast arm, through the narrows, and as far west as Marble creek, in Rupert arm. It also appears on the west shore of the Southeast arm, and on the West arm. It has been mapped separately and named provisionally the Quatsino limestone. Above and below it, interbedded with thin flows and beds of tuff, are numerous thin beds of similar limestone, in places slightly argillaceous. The limestone contains all the copper deposits of the district, which are invariably situated at the contacts of the intrusive diorites and related rocks.

The rocks of the Vancouver group are steeply folded along a northeast and southwest direction, and in the region examined the dips are very consistently to the west. Considerable faulting has also occurred, particularly in the region where the main channel of the sound branches out into the various arms.

These rocks are the oldest in the district, but their age has not been very definitely determined. They are known to be older than the intrusion of the Coast Range batholith which is in part Jurassic, and are, therefore, placed in the Triassic. The writer collected a number of fossils from the formation, which, as yet, have not been determined.

The Coast Range batholith is represented in this part of Vancouver island by a few small intrusions which outcrop usually only on the tops of the mountain ranges.

Economically they are the most important rocks in the district, since all the copper deposits are directly associated with them. They range in composition from true granites to true diorites, quartz diorites and granodiorites being the most abundant.

An intrusion of this period, outcropping at the east end of Rupert arm, has the composition of a true granite. It is a moderately coarse rock with a pinkish colour and exhibits a large amount of quartz in hand specimens. The feldspar is almost all orthoclase with only subsidiary amounts of albite and oligoclase. The chief femic mineral is biotite, but hornblende is also present. At the head of Ingersoll river was found a large mass of quartz diorite consisting of quartz, andesine, augite, and magnetite. Near the Yreka Copper mine on the west shore of the Southeast arm was found an intrusion of the same rock which is probably a part of the same mass. The rock which produced the mineralization at the Old Sport mine is a true diorite consisting of labradorite and augite with little or no quartz and no alkali feldspar.

The rocks of the district classed as Cretaceous are confined to three small areas: one on the north shore of the West arm extending about 2 miles east and west of Coal harbour; another on the north shore of the main channel of the sound extending west from near Quatsino village to Koprino harbour; and a third to the northwest of Winter harbour. The rocks are chiefly sandstone and conglomerate with a little shale and some coal. The conglomerates are quite thick, and coarse, the pebbles being well rounded and averaging about 4 inches in diameter. They consist of andesite, tuff, limestone, and, in places, for example at Koprino harbour, of granodiorite. The sandstone is yellowish grey in colour and rather coarse-grained, containing in places many fossils. The shale is greyish black in colour, usually quite massive and always only sparingly fossiliferous, the fossils being as a rule well preserved.

The only igneous rocks later than the Cretaceous are a few diabase dykes found cutting the sandstone in two places. These dykes are small in size and very few in number, but some of the numerous dykes of a similar composition found cutting the Vancouver formations where there is no Cretaceous exposed possibly belong to this period of intrusion.

Glacial deposits are very widespread in the district and some of the present streams cut through thick beds of coarse, unstratified till. In some places the material is well sorted and stratified, the best examples of this being the beds of sand and gravel at the site of the pulp-mill on the east shore of the Southeast arm where the stratified sands lie horizontally on a beautifully striated surface of andesite and are overlain by thick beds of coarse unstratified till.

Economic Geology.

Copper, iron, gold, and coal are found along the shores of Quatsino sound, but of these copper only has been produced commercially up to the present time. The Yreka mine has already produced considerable copper, and the Old Sport is now being developed on a large scale. A small amount of iron was shipped from a deposit of limonite on the West arm many years ago, and a steamship is said to have supplied itself at one time with coal from a shaft on the west side of Coal harbour.

The Old Sport mine, situated on Elk lake about 6 miles from the east shore of the Southeast arm, is now being extensively developed by the Coast Copper Company, whose intention it is to build a railway from the mine to the beach when sufficient ore has been proved, and a concentrator built.

Up to the present the development work consists of an adit which crosscuts the ore at a distance of about 400 feet from the surface, a drift along the ore-body in each direction for 300 feet, a winze following the dip of the ore for 525 feet, and a drift in each direction at this level for about 300 feet. Besides this there has been a great deal of surface work done and considerable diamond drilling. At the time of the visit work was progressing in the drifts on the lower level and a diamond drill was in operation.

The mine is at present equipped with a water-power plant of sufficient power to drive two compressors which deliver enough air at the mine to operate two drills and a hoist. A crew of about thirty men is employed, and a comfortable camp is established on the shore of Elk lake.

The geological relations of the Old Sport ore-body are illustrated diagramatically in Figure 1. It will be seen that the Quatsino limestone overlies a thick flow of

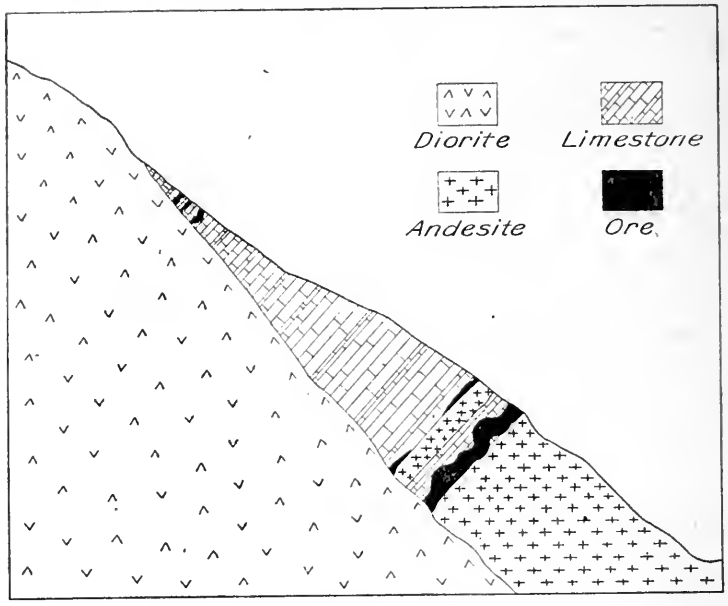

Figure 1. Sketch illustrating the geological features at the Old Sport mine, Quatsino, B.C.

andesite and has interbedded in it, near its base, a much thinner flow of andesite as well as some very thin beds of tuff. The main concentration of ore is confined to the bed of limestone lying between the two andesite flows. The whole series has been cut by a large intrusion of diorite which has extensively metamorphosed both the limestone and the andesite, and evidently produced the ore.

The intrusion is a true diorite, having a dark grey colour and medium coarse texture, and consisting essentially of labradorite, biotite, and augite.

The limestone where unaltered, is very fine-grained, exceptionally pure, and well crystallized. It is, however, intensely altered in the vicinity of the mine. The altered parts are extensive, but their outlines against the unaltered parts are remarkably sharp, and the unaltered parts contain no secondary minerals whatever. The altered limestone now consists of garnet, quartz, epidote, serpentine, and actinolite, the latter being abundant. The sulphides and magnetite are largely confined to highly altered limestone and best developed in the garnetite, but some chalcopyrite and pyrite are also found in the altered andesite.

The alteration of the volcanic rocks is also intense and widespread, even occurring at a considerable distance from the exposed contact of the intrusion. This is thought to be due to the sloping nature of the contact and its being brought still nearer to the surface by the steep slope of the hillside. The secondary minerals most commonly developed are quartz, epidote, and actinolite. The alteration to quartz frequently takes the form of a closely spaced series of parallel replacement quartz veins, a quarter of an inch or less in width, though there is also considerable incipient silicification.

The principal commercial ore mineral of the Old Sport mine as well as that of the district is chalcopyrite, which occurs both as small rounded grains and large irre-

gular bodies several feet in diameter associated with a large amount of magnetite, smaller amounts of pyrite and pyrrhotite, and a very small amount of gold. Pyrrhotite in general is much more plentiful in those deposits situated close to the contact of the diorite, and chalcopyrite is more plentiful in those deposits situated at a distance from the contact.

There can be little doubt that the copper originated with the magma of the diorite, and was carried up into the limestone and andesite by solutions and vapours which passed along joints and bedding planes and was finally deposited where the proper conditions were reached. Owing to the more insoluble and, therefore, more impervious character of the volcanic rocks, the mineralizing solutions would be, to some extent, guided by them, and have a tendency to develop large channels along the contacts with the more easily soluble limestone and form the largest deposits there. Many basic dykes crosscut the ore. These, similarly, would be relatively impervious and at their intersections with the andesite flows would form troughs in which the invading solutions would be more or less trapped and induced to form rich ore-shoots. In the case of the narrow band of limestone enclosed by the two beds of andesite, as shown on the diagrammatic section, the conditions are as outlined above and, as might be expected, the best ore-bodies are in this bed.

In the Old Sport property, the depth of the ore-body will obviously depend on the position of the diorite contact and this has not yet been determined. The present workings go to a depth of about 500 feet measured along the inclined ore-body, and since very little pyrrhotite is present there and no noticeable increase in amount of it has been detected, it might be expected that the contact is still a considerable distance away, and that the ore will persist much farther. The length of the body has been proved on the surface for a distance of nearly 3,000 feet, so that the ore-body is one of considerable size. The assay plan of the upper level shows copper values from 0 to 9 per cent, and low but persistent gold values.

However, owing to the very great irregularity in the distribution of the sulphide, the value of the deposit can be estimated only by careful sampling on a large scale, and at the best it will be a low grade mine. This irregularity in the distribution of the ore is the great drawback to all the contact metamorphic deposits of the west coast and the one that makes them both difficult and uncertain to work.

The Merry Widow is a group of claims adjoining the Old Sport group on the southwest, and containing copper deposits of the same type and of a similar origin. The main workings are situated about 1,000 feet higher up the mountain and almost adjacent to the outcrop of the diorite contact with the limestone. They contain all the minerals that are found in the Old Sport, but there is a much larger proportion of pyrrhotite and smaller proportion of chalcopyrite. Magnetite is also more abundant in these deposits, thus making them lower grade than the Old Sport. Their depth must be much less since the diorite contact passes under them close to the surface, and they are not well enough grouped to form a continuous ore-body of any size.

The Independence group joins the Merry Widow on the southeast. The deposits are situated in the limestone at approximately the same distance from the diorite as the Old Sport and the limestone in the vicinity is highly metamorphosed. There are many small showings of copper on this property and considerable work has been done, though none of it on a large scale. The showings are not related to any volcanic rocks and have no system apparent in their arrangement. No ore-bodies of commercial value have been discovered as yet.

The Yreka mine is situated about a mile in a southwest direction from a point on the west shore of the Southeast arm of Quatsino sound about 4 miles south of its mouth. It is located near the top of a steep mountain slope which rises abruptly from the water's edge to an elevation of over 2,000 feet. The mine is connected with the bunkers on the beach by an aerial tram-line and a wagon road.

The claims were first staked in 1898 and 1899 and the deposit was operated almost continuously until 1903. At that time it was being operated by the Northwestern

Smelting and Refining Company, of Crofton, B.C. After that date it remained idle until 1916, when N. S. Clark and some associates of Spokane again resumed work on it. Considerable money was spent on machinery and in providing transportation, and during that year 900 tons of ore were shipped. The grade proved to be too low for further treatment and the owners closed down the property.

The Yreka is also a contact metamorphic deposit and its geology is similar to that of the Old Sport. The rocks of the Vancouver group here consist of limestones interbedded with andesite flows and thin beds of tuff and are intruded by a small batholith or stock of quartz diorite which outcrops along the top of the mountain range. The bedded limestones and tuffs strike north 50 degrees west and dip 16 degrees to the southwest. They are cut by a number of large granite porphyry dykes adjacent to which are found the ore-bodies. The limestones and tuffs are highly altered, the former consisting of garnet, quartz, green biotite, hornblende, augite, and late veins of calcite that cut through the garnet crystals. The volcanic rocks are altered to quartz, sericite, and epidote. The ore consists of large bodies of sulphide, chiefly pyrrhotite, situated in the garnetite. A small amount of chalcopyrite is contained in the pyrrhotite and some of the assays show low silver values.

The ore that was shipped ran in the neighbourhood of 3 per cent copper, and there are showings on the property that would lead one to believe that a large amount of ore of that grade and a little lower may still be developed. Though such ore is too low grade to ship under present conditions, yet the property might become a commercial proposition if sufficient ore were proved to warrant the erection of a small concentrator. The ore-body exposed at present does not extend into the hill any distance, but there is a good chance of ore being present down the hill in a northeasterly direction and along the line of the strike of the granite porphyry dykes.

The Teta River Gold claims, situated a mile up Teta river from where it flows into the Southeast arm of Quatsino sound, should properly be called the Quatsino King group, but are best known by the former name. The property has a long history, and is now owned by the Quatsino Mining Company of Quatsino. In 1916 and 1917 it was bonded to the Granby Consolidated Mining, Smelting, and Power Company who prospected it by diamond drilling as a possible source for siliceous flux carrying enough gold to pay for its handling. The results were not satisfactory and the bond was dropped.

The deposit occurs in a highly altered area of the Vancouver limestones and tuffs. The surface showing consists of a large mass of nearly pure quartz about 16 feet wide striking parallel to the folding. A short distance below the surface lies an intrusive body of granodiorite, which evidently caused the extensive metamorphism of the limestones and tuffs. Tunnelling and drilling have shown that the mass of quartz on the surface splits up into a few veins cutting a highly sericitized and otherwise altered rock, the original nature of which cannot be distinguished. At a depth varying from 50 to 150 feet the veins enter the granodiorite and fade out.

In the quartz and the silicified rocks there occur small amounts of copper and iron sulphide and in places a little gold. The copper content is insignificant, and hope for the property lies in its gold values. Some very good assays have been obtained by its owners, but the systematic sampling of the Granby Company shows that the gold contents are too low to make it a workable mine.

Millington Group. A deposit of bornite of considerable scientific interest, though doubtful commercial value, occurs about 2½ miles up Spruce river which flows into the head of the West arm of Quatsino sound. At the time of the examination it was owned and was being operated by the Spooner brothers of Holberg. The deposit is situated in the bed of a small creek on the mountain slope to the west of Spruce river, at an elevation of about 700 feet. The only rock found in the neighbourhood is a highly amygdaloidal basalt much fresher than the ordinary members of the Vancouver group. It outcrops for a vertical distance of over 1,000 feet. At several places somewhat close together about halfway up the slope, the rock is seen to contain small,

irregular masses of bornite up to a foot in width and associated with small stringers of chalcopyrite. In the immediate vicinity of these masses of sulphide the rock also contains disseminated grains of bornite which are frequently found in the amygdules. A small amount of probably secondary chalcocite was also observed.

The deposit appears to belong to that class of mineral deposit in which native copper is sparingly concentrated in a basic lava, usually associated with zeolites. The peculiar thing about this deposit is, that there is no native copper and very little chalcopyrite. However, in the same flow about 3 miles to the east, native copper does occur in small veins and as disseminated grains associated with the amygdules. In both these occurrences the amount of copper is much too small to make it worth mining.

OTHER MINERAL LOCALITIES OF THE WEST COAST.

The last three weeks of the season were spent by the writer in cruising down the west coast of Vancouver island, and visiting as many mineral localities as time and circumstances would permit. Owing to the lateness of the season and the difficulty experienced in finding the various prospects without the assistance of local guides, many of the deposits, and even some of the best, were not examined. Some prospecting was done and such observations on the geology of the region made, as would suffice to outline plans for further work.

Seven copper deposits, one mercury deposit, an occurrence of natroalunite, a marble quarry, and a beach placer were visited. A description of all these deposits can not be made in this report, but most of them are described by W. M. Brewer in the Annual Report of the Minister of Mines of British Columbia for 1916 and 1917, and for all particulars as to location, ownership, development work, etc., the reader is referred to those publications. The natroalunite deposit is well described by C. H. Clapp in the Summary Report, Geological Survey, Canada, 1913, and the marble quarry situated in Nootka sound is described by William A. Parks in volume V of his report on the building stones of Canada, published by the Mines Branch, Department of Mines, Canada. A brief description of the mercury deposit which occurs near Sechart channel in Barclay sound will be found in a report by Mr. Camsell in this volume. Only two of the copper deposits visited have reached the producing stage, namely, the Indian Chief situated in Sydney inlet and the Monitor situated near the entrance to Alberni canal.

The Indian Chief group, now owned and operated by the Tidewater Copper Company, has been worked at many times and by many different companies since 1897 and has produced a lot of high grade ore. At present it is equipped with a small oil-flotation concentrating-mill which is situated on the beach and connected with the mine by an aerial tram.

The ore, which consists of bornite with small amounts of chalcopyrite and chalcocite, occurs in a garnetized limestone, capping a hill composed of granodiorite. The contact of the granodiorite and limestone is traceable completely around the hill near the summit and from 100 to 200 feet below the ore-bodies. The plane of the contact is dome-shaped and passes at no great depth below the summit of the mountain. The limestone except at the very top of the mountain is metamorphosed and signs of mineralization are plentiful. Some very rich bodies of bornite have been extracted from both the north and south sides of the hill and some smaller ore-shoots have been discovered in the main tunnel on the south side.

The mill, which was completed only a little over a year ago, was operated for a few months only and at a considerable loss. This was partly due to the unsatisfactory nature of the machinery in the mill and partly due to an irregular supply of ore often of too low grade. The mill was shut down and a shipment of picked ore was made direct to the smelter. At the time of the examination a small force of miners was carrying on development work in the main tunnel.

Unless some large ore-bodies are discovered and developed in the ground between the north and south workings there seems little hope of continuing operations.

Monitor Group. This group of claims is situated on the north shore of Alberni canal just at its entrance, the mineralized zone extending back from the shore several thousand feet. The property was discovered in 1898 and during 1900 and 1901 steadily produced ore which was shipped to the Tacoma smelter. From 1902 it remained virtually idle until 1916. The present owner, Mr. Leonard Frank of Alberni, bought the property some years ago at a tax sale. Since 1916 it has been leased to James Skeen of Seattle, who has done considerable work on the various showings that have been discovered since his taking charge, and has installed considerable expensive equipment.

It is a contact metamorphic deposit occurring in a bed of limestone interbedded with basic volcanic rocks of the Vancouver group. The bedding strikes north 65 degrees west and dips 20 degrees to the southwest. The rocks are intruded by a large body of granodiorite porphyry, probably a dyke, lying west of the deposits striking in a northerly direction.

The ore consists of pyrrhotite and chalcopyrite with small amounts of magnetite and pyrite. It occurs chiefly in the altered limestone, which consists of calcite, quartz, garnet, epidote, and actinolite. Some of the ore is found in the metamorphosed volcanic rocks which are altered to epidote, chlorite, and hematite.

Like all the deposits of this type found on the west coast of Vancouver island the ore is very irregular and the value of the mine, therefore, difficult to estimate. A considerable tonnage of shipping ore averaging 8 per cent copper has been proved and in the new showings there are large lenses of concentrating ore of medium low grade, but it is doubtful if sufficient ore has been proved to warrant the installation of a concentrating plant.

At the time of the examination the mine was shut down, on account of financial difficulties.

The Wreck Bay Beach Placers. Lying between Kennedy lake and the west coast of the island, and extending from Ucluelet to Tofino inlet is a flat coastal plain composed of unconsolidated sands, fine gravels, and thin beds of blue clay. The plain is about 60 feet above sea-level, and is bounded along the coast by a perpendicular wave-cut cliff at the foot of which is a beautiful beach sloping gradually out to sea.

These sediments contain a small amount of black sand and fine gold which is being continually concentrated at the base of the cliff by the action of the waves. Prospectors and campers come periodically and clean up the gold by panning the black sand found at the foot of the cliff. Several attempts have been made recently to use small concentrating machines operated by hand or by small gasoline engines, but the amount of sand is too small and is soon worked out. A number of years ago some of the local settlers organized a company and installed a flume and sluice boxes from which were obtained several thousand dollars worth of gold, this being the first time these wave-washed concentrates had been worked.

The gold probably comes from the gold-bearing quartz veins that are known to occur in the mountains to the west of Kennedy lake. The quantity of gold in the sediments is much too small to be extracted commercially by working them where concentration has not already been effected by wave action.

CARIBOO GOLD FIELDS, BRITISH COLUMBIA.

By B. R. MacKay.

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INTRODUCTION.

The Cariboo gold fields embrace an area of 7,000 square miles and lie within the great bend of the Fraser river between the Canadian Pacific and the Grand Trunk Pacific railways, the mining centre of the district being at Barkerville, 230 miles directly north of Ashcroft on the Canadian Pacific railway. The area may be said to be bounded on the south by Horsefly river, on the east by the Cariboo range, on the north by the parallel of latitude passing through the headwaters of Government creek, and on the west by Fraser river.

Of the total placer gold production of British Columbia, amounting to a little over $75,000,000, almost $45,000,000 is officially reported as having been derived from the placer deposits of this field, and it is altogether probable the output was much greater. Although the greater part of this yield was obtained between the years 1860 and 1878 when the rich accessible parts of the stream beds within the area were mined, the area still has, in spite of the great difficulties to be overcome, an average annual production of about $200,000. Owing to the abnormal conditions brought about by the world war, the scarcity of labour, the difficulty of raising capital, the high cost of mining machinery and in some cases the impossibility of obtaining the required machinery, taken in conjunction with the fact that the price of the metal mined has remained stationary, it is natural that there should be a great reduction in placer mining operations in this as in other gold placer fields, and the output for 1918 was only $82,000. Had it not been that costly plants had been installed, which would have suffered greatly by lying idle, the decrease in output would have been much greater, as these plants continued work even though in most cases they did not make expenses. With the return of normal conditions and the completion into this area of the Pacific Great Eastern railway, now under construction, there should be a marked rejuvenation in the placer mining industry of this region. In view of this it was deemed advisable by the Geological Survey that further assistance should be given by continuing the investigation of these deposits, commenced many years ago by Dawson and Bowman; the study to take the form of tracing and mapping channels already discovered, and searching for channels not yet located.

With a view to planning future work along this line two months of the field season of 1918 were spent by the writer in a reconnaissance survey of the Cariboo gold fields and in visiting the various placer mining operations within the area. Lack

of time prevented visits being made to a few of the outlying localities where smaller placer operations were being carried on, and to the several lode deposits on which considerable work is being done.

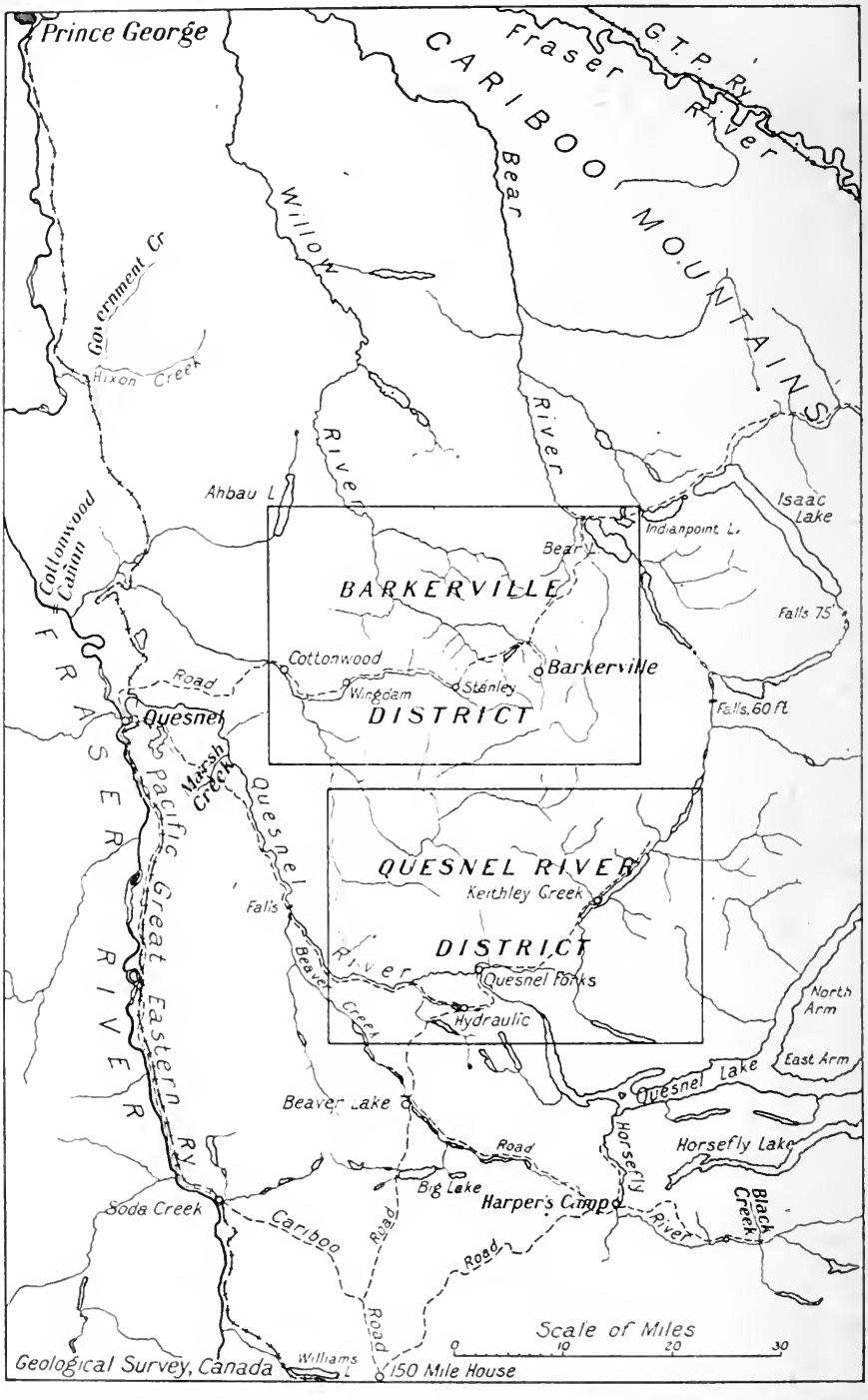


Figure 2. Index map showing location of the two principal areas in which placer operations are at present being carried on and the location of other placer deposits referred to in text.

T. A. Link acted as assistant and rendered efficient service. Throughout the work the utmost assistance was received from the numerous mining operators and their officials within the area, and even the residents of the district, not directly interested in the mining activities, were anxious to assist in every way possible. To all these the writer desires to convey his sincere thanks for the many favours shown him. Acknowledgments are especially due Mr. John Hopp and Mr. M. Bailey for the loan of valuable mine plans and private reports, also Mr. H. W. Dodd, Gold Commissioner, for the many courtesies received.

The following is a brief description of the deposits at present being worked and the future outlook as it appears to the writer. The locations of the various deposits referred to are indicated on the accompanying sketch maps, Figures 2, 3, and 4. Transverse sections of a few of the deposits being worked are also shown. For further data relating to the geology and deposits of this district those interested are referred to the early reports of the Geological Survey by G. M. Dawson and Amos Bowman, and to the annual reports of the Minister of Mines, British Columbia. Of these latter the report of the year 1902 will be found of special interest as it contains a very complete treatment of the placer deposits and the mining operations then in progress, by Mr. Wm. Fleet Robertson, Provincial Mineralogist. In 1914 the mining operations of the district were reported on by Mr. J. D. Galloway, then Assistant Provincial Mineralogist, and an annual report is now submitted by Mr. Galloway as resident engineer of the district.

Accessibility.

The area may be easily reached by automobiles from Ashcroft on the Canadian Pacific railway, or by steamer from Prince George on the Grand Trunk Pacific railway. The Pacific Great Eastern railway, which is to run from Vancouver to Prince George, passing along the western border of the district, is now under construction and is expected to be completed in the near future.

During the navigable season of 1918 two boats made semi-weekly trips from Prince George down the river. The large steamer, *B. X.*, owned by the British Columbia Express Company, ran between Fort George and Soda creek, and the gasoline yacht, *Circle W.*, carried mail and passengers from Prince George to Quesnel.

Throughout the past summer, in addition to the regular mail stage which made two trips a week from Ashcroft to Barkerville, a distance of 285 miles, at least ten automobiles were constantly in public service conveying passengers to and from the various centres within the area. Good roads connect Harpers Camp and Quesnel Forks with 150-mile House on the Cariboo road and with the exception of the Cariboo Lake area practically all the mining centres within the district may be reached by automobile.

A winter road 18 miles in length connects Keithley Creek with Quesnel Forks. Some of the old pack trails connecting Keithley Creek with the other mining centres in the district are still serviceable and new trails are being made where needed.

Topography and Relief.

The Cariboo gold fields embrace parts of two physiographic provinces, the Cariboo Mountain province and the Interior Plateau province. The Cariboo Mountain province which occupies the eastern part of the area is characterized by a series of northwest-southeast mountain ranges forming the northern extension of the Columbia system of mountains. The Cariboo range, the castellated peaks of which attain an elevation of 8,000 feet and are covered with perennial snows, is the principal range of this group. The other mountain ranges lying to the west rise to an elevation of about 6,500 feet. Two systems of major valleys occur in this part of the area, a northwest-southeast system separating the mountain ranges and a northeast-southwest system cutting across them. These valleys are deep, wide, and flat-bottomed, having

been floored for a depth of several hundred feet by glacial drift and outwash and recent stream gravels. As these valley flats lie at an altitude of about 2,500 feet the relief of this part of the area approximates 5,500 feet.

The Interior Plateau province, which embraces the remaining part of the area, merges imperceptibly into the Cariboo Mountain province. In the vicinity of mount Agnes and Snowshoe mountain remnants of this plateau occur as even-crested and flat-topped ridges at an elevation of about 5,500 feet, but followed westward the plateau decreases gradually in elevation until in the neighbourhood of Quesnel and Fraser rivers it lies at an altitude of about 3,500 feet. Into this plateau have been cut deep, broad valleys which have been later filled for several hundred feet with glacial drift, gravels, and silts. Into this unconsolidated material the streams have cut deep gorges. The valley slopes of the smaller streams are precipitous from top to bottom, but those of the larger streams, such as the Fraser, Quesnel, and Cottonwood, are broken by a series of gravel and silt benches marking stages in the lowering of the valley from the upland to the level of the present beds of the streams which lie at an elevation of about 1,500 feet.

Glaciation.

Beyond the subdued topographic outline of most of the peaks within the area and the occurrence of small boulders of foreign origin on the tops of the peaks at an elevation of 6,400 feet, there is little to indicate that the area was completely covered by an extensive ice-sheet. Post-glacial weathering on the uplands has been so severe that no evidence such as striæ could be found to indicate the direction of glacial movement. In the lower altitudes, the slopes are so buried in glacial debris and covered with such a thick forest growth that few outcrops occur. Insufficient evidence has been collected to determine the direction of movement of the ice, but from the erratics so far noted in different parts of the area, the movement appears to have been from northeast to southwest, which direction is about at right angles to the trend of the Cariboo range forming the eastern border of the area.

The changes affected by alpine glaciation are much more pronounced. Deep-cut cirque basins bounded by precipitous walls are sculptured on the high peaks of the Cariboo range and on the northern flanks of many of the lower peaks within the area. On the slope of some of these peaks, as at mount Agnes lying just south of Barkerville, large compound cirques exist having several rock basins, in some of which small lakes occur and in others accumulations of snow remain throughout the summer. At the mouths of some of the cirques well-developed moraine ridges are to be found, whereas at the mouths of others these accumulations are entirely absent and the valleys leading from them have the U-shaped cross-section characteristic of intense glacial erosion.

Lower down the valley, glacial erosion gives place to glacial deposition. This part of the valley shows no evidence of glacial scouring and retains its preglacial form. Some of these buried channels are narrow and characterized by interlocking spurs. In many, the preglacial deposits have remained undisturbed, being buried under a thick blanket of glacial till and outwash. In some places the smaller valleys have been completely obliterated, and in the major valleys the deposition of outwash and drift, totalling in some cases hundreds of feet, has effected numerous and marked changes in the drainage. The changes which have taken place in some of the valleys by glacial deposition may be seen in the comparison of the post-glacial and preglacial surfaces shown in the transverse sections given.

PLACER DEPOSITS.

An adequate discussion of the distribution of the placer deposits of this field must await a more complete knowledge of the rock geology of the area, as the period spent in the field was too brief to permit of a study of this phase of the work. Fine

gold has been found along most of the creeks of the area and is so widely scattered that the rich deposits of the Cariboo were discovered by tracing the trail of fine gold from the lower Fraser up that river and its main tributary, the Quesnel, to the mining centre of the district. The coarse gold, however, has not travelled far from its parent source and the majority of the rich workable deposits are confined to the beds of the creeks cutting the Cariboo schist formation. This formation, consisting of slates and schists of various kinds, referred by Bowman to lower Palæozoic age, is exposed in parallel undulations trending in a northwest-southeast direction. These schists are cut by numerous quartz veins, many of which are mineralized with chalcopyrite, pyrite, and galena, and contain appreciable values in free and combined gold. These veins are doubtless the source from which the placers were derived, but whether they will pay to mine has not as yet been demonstrated. Development work along a number of the quartz ledges on Proserpine mountain, 4 miles from Barkerville, is at present being carried on with very encouraging results.

Classification of Placer Deposits.

The placer deposits occurring within the area may be conveniently grouped according to their age and origin into four main classes, which are:

Post-glacial river, bar, and bench gravels.
Post-glacial gulch, creek, and bench gravels.
Preglacial gulch, creek, and bench gravels.
Fluvioglacial gravels.

Post-glacial River, Bar, and Bench Gravels. As already mentioned, fine gold occurs in the gravel bars, stream gravels, and river terraces along the larger streams traversing the area, Fraser, Quesnel, and Horsefly rivers. These were the first deposits to be exploited, being worked largely by panning and ground sluicing. Later, several large dredges were installed at different places along Fraser and Quesnel rivers, but the operations did not prove financially successful and the dredges were abandoned. At present a bench deposit of Horsefly river at Harpers Camp is being worked by means of a drag-line scraper, and plans are under way to mine a deposit along Quesnel river 20 miles from its mouth, by a drag-line dredging plant.

Post-glacial Gulch, Creek, and Bench Gravels. These deposits have been derived from the reassorting of preglacial gravel deposits exposed by stream dissection. As they were easy of access they attracted the early miner and it was not long before all the rich deposits of this type within the area were exhausted. Deposits which were too lean to induce the miner to continue work were left, and on these work is intermittently carried on by Chinese and a few white miners.

Preglacial Gulch, Creek, and Bench Gravels. The preglacial gulch, creek, and bench gravels are the source from which by far the greater part of the output of the Cariboo area is at present derived. Owing to the fact that these deposits occur in most cases buried under a heavy mantle of drift, glacial outwash, and recent stream gravels, many of the deposits were entirely overlooked or the mining of them had to be abandoned due to water and other difficulties. Even where it was possible to mine the deposits by drifting, only material of sufficient richness to pay the expense of mining was touched and consequently much ground that could not then be worked profitably is now available for handling by the more recent and cheaper methods. The great changes in drainage brought about by the deposition of glacial drift in the valleys in which these deposits occur, in some cases obscuring completely the preglacial topography, makes the tracing of these deposits a matter of detailed study and mapping.

Fluvioglacial Deposits. These deposits are especially abundant along the valley of Quesnel, Fraser, and the neighbouring tributary streams, as in this vicinity deposits of clay, outwash gravel, and silt occur, being in places over 400 feet in thickness. Since

the values in these gravels occur as fine particles of gold and platinum disseminated throughout the deposit, with few if any well-defined paystreaks, the deposits are generally of low grade and should be thoroughly sampled before any great outlay of capital is warranted. In sampling the deposit, care must be taken not to take the values found on a gravel bench as being representative of the whole bank, as these have arisen from the reassorting of the gravels of the part of the bank removed, and the fact that the bench gravels pay to mine is no indication that the whole bank will pay to work.

PLACER MINING OPERATIONS IN CARIBOO AREA.

Cariboo Mining Division.[1]

Hopp Mines. To Mr. John Hopp more than to any other man in the Cariboo area is due the credit for the continued high output of this camp. With the able assistance of Mr. M. Bailey, engineer, and Mr. L. Muller, foreman, Mr. Hopp has continued hydraulic operations in spite of the adverse conditions which compelled many other operators to close down their plants. At present hydraulic mining is being carried on by him on Lowhee creek, Stouts gulch, and Mosquito creek.

The great handicap in the hydraulic mining of these three deposits is scarcity of water. Due to the altitude of this part of the area, which is over 4,000 feet above sea-level, no large drainage basins exist and the necessary water must be collected from what small catchment basins there are. For this purpose Mr. Hopp has an elaborate system of ditches totalling over 32 miles in length, tapping the small drainage basins where possible, and fringing the mountains collecting the run-off water. Even in the most favourable seasons, however, there is not sufficient water available to keep hydraulic mining operations in progress throughout the workable season. A number of years ago Mr. Hopp had a plan under way to overcome this obstacle by installing a large pumping station at the north end of Jack of Clubs lake, the plant to be run by electric power generated by falls on Swamp river. By means of this, water from the lake was to be pumped to the Lowhee ditch for use in the Lowhee mine, and to a reservoir on Island mountain for use in the mining of the Mosquito Creek deposit. In the Lowhee ditch scheme the water would be practically in a circulating system, being pumped into the ditch and, after being used in the hydraulic operations, returning to the lake. In the Mosquito Creek system the water after being used in the hydraulicking of the deposit would drain into Willow river. As the lake has a depth of over 200 feet in places, sufficient water was available for the undertaking. As with other projects under way, however, with the outbreak of the world war this scheme had to be abandoned.

Lowhee Creek. Lowhee creek flows northward into Willow river, joining it just east of Jack of Clubs lake. The preglacial channel of this creek has been uncovered for a distance of 4,000 feet, along which distance it is narrow, averaging about 300 feet in width and characterized by interlocking spurs. The channel bed, having an average width of about 70 feet, is covered by preglacial gravels, boulder clay, and later gravels to a depth of 150 feet.

The transverse sections represented on Figure 5 show the configuration of the preglacial valley and the approximate extension of the surface prior to hydraulic operations. Section 1 was taken at the present workings 4,000 feet above the lower end of the pit. Section 2 was taken near the company's cook-house 2,000 feet above the lower end of the pit. The latter section shows besides the deep channel a still older channel about 30 feet in width and lying about 60 feet above it. Remnants of this older channel occur as rock benches at several places along the valley.

Although the paystreaks were found principally in the gravels lying near or on bedrock of the deep channel and the bench, considerable values were evidently dissem-

[1]For location of properties referred to in text see Figures 2 and 3.

inated throughout the gravels, as old workings show the deposit to have been worked in a series of three or more levels.

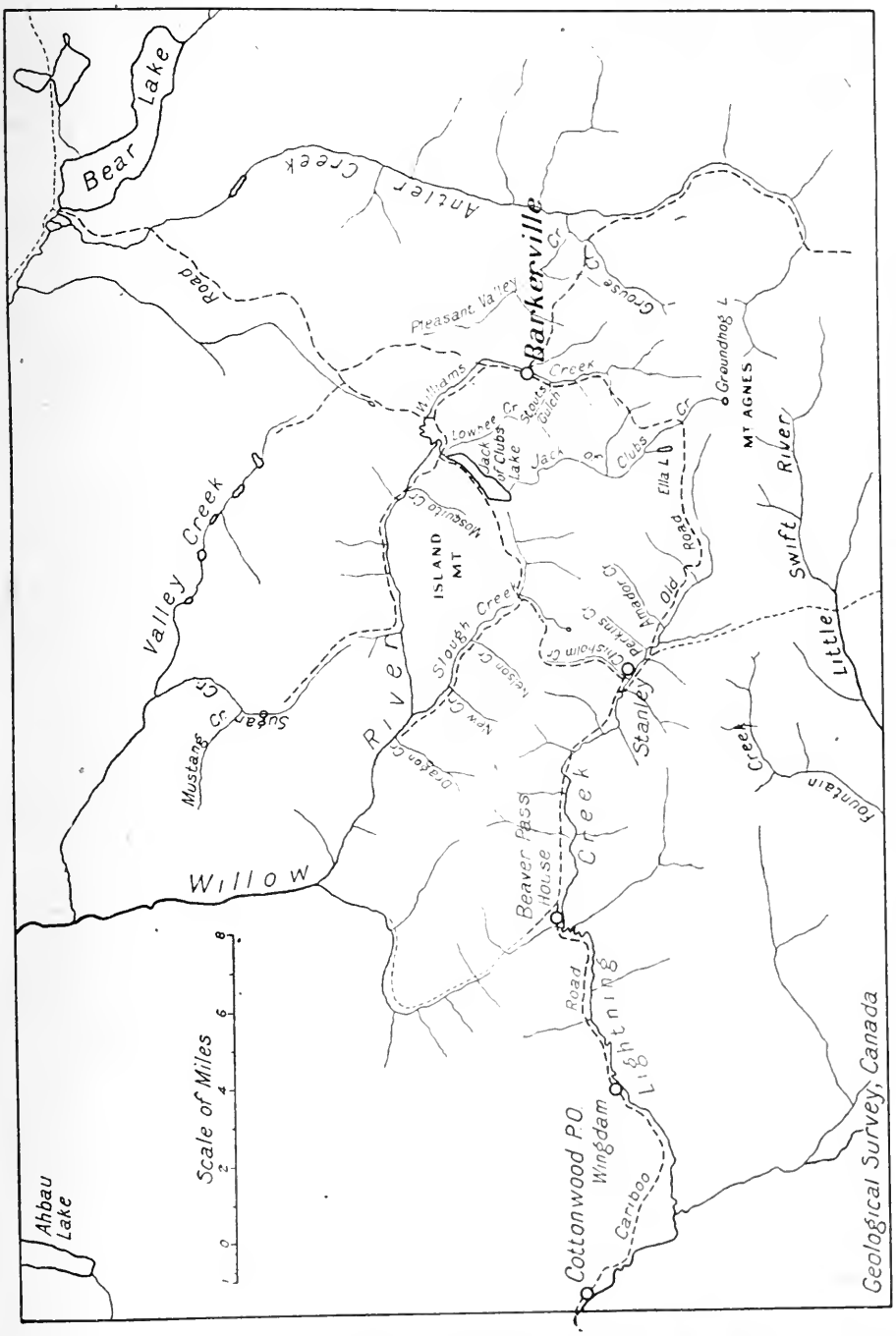


Figure 3. Barkerville district showing location of streams along which occur placer deposits referred to in text.

Hydraulic mining of this deposit has been carried on by Mr. Hopp for a number of years, and the plant installed is one of the most up-to-date plants in operation in the province. Water gathered from Lightning creek, Jack of Clubs creek, and several

smaller streams is conveyed to the workings by means of 14 miles of ditches; Ella lake, a depression lying in a tributary valley to that of Jack of Clubs creek, 4 miles south of Jack of Clubs lake, being used as the main storage reservoir. From a penstock on the west side of the channel a 250-foot head of water is supplied to two monitors having 8-inch and 9-inch nozzles. The main sluice flume, 4 feet by 6 feet cross-section, is 3,750 feet in length, with a gradient of 4·35 per cent. Throughout its length it is paved with wooden blocks 10 inches in height and 10 inches to 15 inches in diameter, the transverse rows being separated by strips of timber one inch in thickness. Along the upper part of the course, the main flume is accompanied by a smaller flume 3 feet by 3 feet cross-section, into which the water may be diverted and the gravels washed while the clean-up and repaving in the main flume is taking place. Better dumping facilities could not be desired. From the lower end of the sluice boxes to the level of Jack of Clubs lake, about 1 mile distant, there is a drop of about 500 feet in elevation, and the dumpage room is easily sufficient to take care of all the material of the deposit.

The great handicaps in the hydraulic mining of this deposit are the excessive length of flume with its consequent heavy cost of upkeep in paving, the large boulders met with in the deposit which require blasting before they can be run through the sluice boxes, and, as already mentioned, the scarcity of water. This latter difficulty has been somewhat overcome by diverting the water caught in the Ground Hog Lake reservoir and the Cariboo gold field ditch, which water is generally used in the hydraulic operations of Stouts Gulch deposits, into the Lowhee drain; but even with this extra supply there is not sufficient water available to keep mining operations continuously in progress throughout the workable season.

Over 4,000 feet of the buried channel still remains to be mined, the greater part of which is virgin ground. As the hydraulic operations up to the present in ground previously drifted by the early miners, have paid handsomely, and as the gravels exploited at the summit between Lowhee creek and Stouts gulch contained high values, very rich returns from the intervening unworked section are probable.

Stouts Gulch. Stouts gulch is a southward trending tributary valley of Williams Creek valley, entering the latter a short distance above the town of Barkerville. Unlike Lowhee gulch the preglacial channel is shallow and much wider, being over 700 feet in width. The great width of this channel with respect to the length of the gulch, which is a little more than a mile, is exceptional and indicates that the channel is part of some larger drainage system. The channel has been hydraulicked out for the greater part of its length, though untouched parts still remain along the sides. Section 3, Figure 5, taken at the workings about 2,600 feet from the mouth of the stream, shows the deep channel to be about 200 feet in width and to have been covered by 85 feet of overburden of which the lower 30 feet were gravel and the upper 55 feet were boulder clay and later gravels. Remnants of a bench about 300 feet in width, lying 20 to 30 feet above the deep channel, occur for a distance on the south side of the channel.

As in the other deposits the main values were found in the gravels, both in the deep channel and on the bench, concentrated on bedrock, and in the crevices of the schist which has weathered to a distance of several feet below the surface. Some gold was found, however, concentrated on a false bedding of boulder clay, evidently deposited there by later wash from a tributary valley on the south side.

At the upper end of the pit the bedrock surface slopes off toward Lowhee creek, indicating that the divide between these two preglacial channels has been crossed. It is worthy of note that high values in gold were recovered from bedrock up over this summit, and down the other slope. The total gold yield from this gulch is estimated at $2,500,000.

The water used in the hydraulic operations of this deposit is collected from the headwaters of Lightning and Jack of Clubs creeks and from the slopes of the mountains in the neighbourhood of the deposit. Twelve miles of ditches are used for collecting and conveying the water to the workings. Ground Hog lake, a cirque lake at

the north base of mount Agnes, has been converted into an excellent reservoir by the construction of a dam across its outlet. As this reservoir, and the ditch conveying the water to Stouts Gulch deposit, lie several hundred feet above Lowhee ditch, the former crossing Jack of Clubs creek about 200 feet higher in elevation than the latter, the water collected in the reservoir and the upper part of the ditch can be carried through the waste gate in the ditch, down Jack of Clubs creek and into the Lowhee ditch. As already mentioned, during the dry season when there is insufficient water to work both these deposits, hydraulic work on Stouts gulch is discontinued and all the water available is used in the Lowhee operations.

Mosquito Creek. Mosquito creek, which is a little more than a mile in length, rises on the slope of Island mountain and flows northeastwardly into Willow river. The stream occupies a wide, shallow valley and throughout the greater part of its course runs on glacial drift. In the lower part of the stream course where the preglacial channel has been exposed for a considerable distance by hydraulic operations, the overburden, consisting of gravel and boulder clay, was found to be from 40 to 100 feet in thickness. The width of the channel here was about 800 feet. At the present workings (see Figure 5, Section 4) the main preglacial channel is joined by two tributary channels. No indication of the position of the main channel or the presence of these tributary channels was supplied by the post-glacial topography, the deposition of outwash gravels and boulder clay being so great as to obliterate entirely the preglacial drainage courses.

The values, which have been largely obtained from the buried channels, are exceptionally high. The deposits were first mined by drifting, but sufficient values were left to enable the gravels to be reworked by the hydraulic method. Although the main paystreaks were found in the gravels along the troughs of the buried channels, very rich pay was obtained from a bench running for a distance of 700 feet along the east side of the valley and varying in height from 100 to 150 feet above the bed of the deep channel. The gravel along the paystreak on the bench took the form of a low ridge, being much thicker directly over the paystreak than elsewhere. The presence of a paystreak in such an unprotected place in this wide valley points to the feebleness of glacial erosion in this part of the area.

The gold found is generally very coarse and ragged. Many nuggets occur containing fragments of quartz still adhering to the gold; in some, the quartz forms over half the mass. Much crystallized gold is also met with in the placer deposit, occurring as octahedron and rhombic dodecahedron forms.

The bedrock is highly folded and consists of schists and slates cut by numerous quartz veins from which the gold values in the gravels were in all probability derived.

The water used in hydraulicking this deposit is collected from the northern slope of Island mountain by means of 5 miles of ditches, and at best this supply is only sufficient to give a run for about two months. During the dry seasons hydraulic operations are carried on only a few hours a day or abandoned altogether. The exceptional richness of the deposit, however, makes up for the handicap in mining. Over $3,500,000 is said to have been already derived from this deposit.

Grouse Creek. Grouse creek, a stream 4 miles in length, flows southeasterly into Pleasant Valley creek, entering the latter near its junction with Antler creek. For over thirty years the Waverley Company worked the preglacial channel of this stream having hydraulicked out a pit about 1,200 feet long, 200 feet wide, and over 100 feet deep. Recently a company represented by Messrs. C. W. Moore and J. G. McLaren, has taken over the property and during the past season has had a number of men employed in keystone drilling, erecting a saw-mill, constructing reservoirs, and doing other preliminary work with a view to beginning actual mining operations next summer. The intention is to work the untouched ground lying below and above the pit. At the head of the pit, where drilling operations were being carried on, the channel was about 100 feet in width and lay about 90 feet below the surface. The sluice flume used in the previous mining operations was found to be about 20 feet above the bedrock of the main

channel, and it is expected that the exploiting of these undisturbed gravels will yield rich returns.

Jack of Clubs Creek. This creek rises from the northern slope of mount Agnes and flows westerly and northerly, emptying into the western end of Jack of Clubs lake. At present, Messrs. John McDougall and F. Dewitt Reed are engaged in sinking a 110-foot shaft from the bottom of which they plan driving a 120-foot tunnel to tap the buried channel.

Slough Creek. Slough creek rises near the western end of Jack of Clubs lake and flows northwesterly into Willow river. The creek occupies a valley almost a half mile in width, which undoubtedly was the preglacial drainage course of Williams and Jack of Clubs creeks. Mining operations carried on a number of years ago under the management of Mr. John Hopp showed the preglacial channel to lie 285 feet below the present surface and to be in places almost 600 feet in width. The valley is filled in with gravel and clay, the clay stratum which lies about 50 feet above bedrock being in places 180 feet thick. Owing to the excessive flow of underground water the attempt then made at exploiting these deep deposits proved unsuccessful, but Mr. Hopp is satisfied that the water difficulty will be overcome. No attempt is being made to mine this deep ground at present, the work that is being carried on along the creek being confined to the hydraulicking of beach deposits along the southwestern side of the valley. The banks being worked are almost 100 feet in height, and a generalized section of the deposit as exposed in the different workings is, in descending order, as follows:

Glacial and post-glacial outwash—beds of sand and gravel dipping northwest, about 40 feet thick.
Boulder clay and gravel.
Coarse gravels, auriferous.
Slate bedrock intruded in places by tongues of igneous rock.

The values are largely derived from the lower gravels.

Of the three plants in operation, the Point mine owned by Loo Gee Wing, Vancouver, and run under the management of Mr. Joseph Wendell, is much the largest. Here is installed an up-to-date hydraulic plant for the working of a bench deposit. A face 500 feet in extent is being washed by a series of monitors, the material being run through a series of four sluice boxes converging into a single tail race. In this way the excessive supply of water obtained in the spring through the melting of the snow can be handled, and the work of washing a part of the bank can proceed while the clean-up from another part is being made.

Dragon Creek. Dragon creek, a small northeastward-flowing tributary of Willow river, enters the latter about 2 miles below the junction with Slough creek. During the season Mr. Leo Muller and Mr. Otto Muller were engaged in tunnelling along the buried channel of the creek and obtained very favourable results. Recently Mr. Leo Muller bought out his partner's interest in the claim and is now carrying on the work single handed.

Mustang Creek. Mustang creek, a small creek less than 2 miles in length, flows eastward into Sugar creek. There Messrs. John Bell and Wm. Thompson are engaged in preliminary work with a view to beginning actual mining operations as soon as possible.

Lightning Creek. The only work at present carried on along the main channel of Lightning creek is at Wingdam. Here the Lightning Creek Gold Gravels and Drainage Company, a New York syndicate of which Mr. C. H. Unverzagt is manager, are engaged in developing their property. The Company own extensive holdings along the lower part of this creek, extending from Beaver pass down stream a distance of 20 miles.

Extensive and systematic prospecting by keystone drilling to obtain cross-sections of the valley and the gold values contained in the gravels has been carried on for a distance of about 2 miles along the stream. The buried channel, which has a width of about 100 feet, is found to lie about 165 feet below the present stream bed, and to

be bordered in places by rock terraces 10 to 20 feet high. Both bench and deep channel gravels contain high values in coarse gold, the channel gravels being, however, much the richer.

The great depth at which these deposits lie, and the excessive flow of underground water encountered, are the chief handicaps to the working of these deposits. Although the company has been engaged for a number of years in trying to master the situation, the difficulty is not yet solved. At first the intention was to drain the channel by driving a tunnel from a point sufficiently far down stream to strike bedrock at the desired place of working, but as this would require a tunnel almost 3 miles in length the plan was abandoned as being too expensive an undertaking. Attempts made so far to drain the channel by the pumps placed in the two shafts sunk have proved unsuccessful. Neither the two 12-inch Cornish pumps nor the 4-stage No. 6 turbine pump installed appear to have been equal to the task. Mr. E. S. Will, the assistant manager of the company, feels confident, however, that the water difficulty can be handled, and that soon the company will be able to exploit these apparently rich deposits.

Perkins Gulch. Perkins gulch enters Lightning creek on the north bank about one mile above Stanley. Mr. I. I. Felker and Mr. W. S. Sparkes, after several years spent in a systematic search along the lower part of this stream have finally discovered a very rich deposit a little over a half mile from its mouth. The deposit occurs in a preglacial channel, lying about 30 feet above the present bed of Perkins creek and entering it on the eastern side in a direction almost at right angles to the present course.

The buried channel is wide and flanked on the north side by a terrace over 100 feet in width lying 30 feet above it (Figure 5, Section 5.) The sections exposed in both the deep channel and on the bench are about the same, with the exception that no true boulder clay was to be seen on the latter. its place being taken by a thin bed of silt. The sections are as follows:

—	—	Bench.	Deep channel.
		Feet.	Feet.
	Silt and clay	2	15
Recent to Pleistocene deposits	Fine gravel with sand lenses.	6	7
	Coarse gravel	8	7
			Paystreak.
	Silt	2	
Glacial boulder clay		0	25
Glacial and preglacial gravels shingled upstream, auriferous.		6	6
		Paystreak.	Paystreak.
Decomposed bedrock		1½	2

Fresh bedrock, Cariboo schists, strike north 45 degrees west, dip 42 degrees east.

Paystreaks of both preglacial and post-glacial age occur. Coarse, rugged gold showing little evidence of wear occurs in the preglacial gravels, both on the rock bench and in the deep channel. In some places the gold was found to have worked down a distance of 2 feet in the crevices of the decomposed schist. Another rich paystreak of finer, smoother gold is found in the coarse gravels immediately overlying the boulder clay of the deep channel. Whether this paystreak has been derived by the working over of the bench gravels which occupy the same horizon lying adjacent on the north or whether it owes its origin to the resorting of the deep channel deposits farther up slope is not as yet fully determined, but the former origin is favoured.

Mining is being carried on by means of a small hydraulic plant, the necessary water for which is obtained from the drainage basin of Perkins creek. With the small supply of water available only a short season's run is possible. During much of the time the washing did not exceed a few hours a day and this was made possible by collecting the drainage water in the reservoir during the remainder of the time. To overcome this difficulty Messrs. Felker and Sparkes have procured water rights on Amador creek and plan building a ditch to convey this water to the workings. As yet only a few hundred feet of the channel and bench have been cleared, but the returns from this have been phenomenally rich, over $5,000 being recovered, from a bedrock surface of 100 feet by 150 feet. An attempt is being made to tap the old channel about 1,100 feet farther up, by a tunnel run through rock from the present channel of Perkins creek, and in this way the time during which hydraulic washing can not be carried on will be devoted to drift mining.

Chisholm Creek. Chisholm creek, a small southward-flowing tributary of Lightning creek, enters the latter at the town of Stanley. Although only a little gold was recovered from the present stream bed, the fact that the neighbouring creeks have yielded in varying degrees, led the Cariboo-Chisholm Creek Mining Company, under the management of Mr. J. A. McPherson, to undertake considerable prospecting in the lower part of the creek in search of an old channel.

By means of keystone drilling a buried channel lying about 400 feet west of the present stream and about 30 feet higher than its bed was discovered covered by 180 feet of glacial debris and gravel. The values contained in the gravels induced the company to drive a tunnel 1,300 feet in length from near the present stream channel, a gradient of 5 inches per 100 feet being given the tunnel for drainage purposes. On completing the tunnel it was found to be about 10 feet below the bed of the buried channel and in order to tap this it was necessary to run upraises. The water pressure in the channel, which was found to be great, was relieved gradually by working alternately on the faces of a series of three drifts run from a tunnel paralleling the channel. After draining the channel a considerable amount of exploiting of the gravel deposit was carried on, but the excessive width of the stream bed which at this place exceeded 100 feet prevented any great concentration of values. The channel at this point bears westward at an angle of about 30 degrees with the present course of Chisholm creek.

Owing to the scarcity of labour brought about by the war, development work was discontinued, but will probably be resumed as soon as normal conditions are restored.

Boulder Creek. Boulder creek enters Lightning creek a short distance below Stanley. During part of the season Mr. J. F. Williams was engaged in carrying on ground sluicing which gave satisfactory results.

Cottonwood Canyon. Cottonwood canyon lies on Fraser river about 12 miles above the town of Quesnel. At the foot of the canyon, about 2 miles above the mouth of Cottonwood river, banks of gravel and silt rise to several hundred feet above the level of the water. Over a distance of several hundred feet the lower parts of the banks on both sides of the river consist of streaks of clay, sand, "chicken-feed" gravel, and fragments of wood intimately mixed with numerous boulders of foreign origin, the whole deposit being firmly cemented by percolating solutions. Some of the boulders are very large and many show polished and striated surfaces, the result of glacial action. The deposit lies on bedrock which on the east side of the river is about 25 feet above water-

level and on the west side a little below the level of the water. As far as known to the writer no definite paystreaks occur, but the lower 6 feet of the deposit contains sufficient gold values to attract capital to it as a placer proposition.

For a number of years the deposit on the east side of the river was worked in a small way by Mr. D. Killam, the cemented material being allowed to slack on the dump during the winter, and run through the sluice boxes the following summer. Recently an attempt has been made by the Tertiary Mining Company of Chicago, under the management of Mr. D. D. Fraser, to work the deposit on a much larger scale. The cemented gravel is blasted, loaded into cars of one cubic yard capacity, run to the mouth of the mine, hoisted over a trestle to the top of the mill, and dumped into a large hopper leading into a revolving trommel screen, where it is disintegrated. The screen, which is made of $\frac{3}{8}$-inch steel, is perforated with holes 1 inch in diameter and revolves at a rate of seventeen revolutions per minute. The coarse material passes down the revolving barrel and into a chute leading to the dump; the fine material, passing through the screen, is fed into a sluice box fitted with Hungarian ripples, where the gold values are caught. The area so far stoped out measures about 100 by 150 by 6 feet.

The deposit on the west side of the river is being worked in a small way by Mr. F. DeLong.

Similar deposits of cemented gravel are said to occur along Cottonwood river for a distance of several miles above its mouth.

Government Creek. Government creek, a stream about 10 miles in length, flows southwesterly into Hixon creek a westerly flowing tributary of Fraser river entering about 31 miles north of Quesnel. For a number of years past considerable prospecting has been carried on along the lower part of this creek by Mr. Dougal Cameron and gravels estimated at about 4,000,000 cubic yards are said to average 40 cents per cubic yard in gold and platinum values. At present Mr. Cameron is trying to interest capital in the deposit with the object of installing an hydraulic plant.

Quesnel Mining Division.[1]

Marsh Creek. Although several dredges were operating on different parts of Quesnel river a few years ago, these attempts did not prove financially successful owing to poor management, and since then no further effort has been made at mining the deposits. Recently, however, Mr. S. J. Marsh has procured a strip of dredging ground along the lower part of Marsh creek, which flows northeastward into Quesnel river about 20 miles from its mouth, and along the main river for a distance of 5 miles downstream from the junction of this creek. Considerable prospecting by panning and sluicing has been carried on and high values in gold and platinum are said to have been obtained. Mr. Marsh is endeavouring to raise capital with a view to installing a drag-line dredging plant to work the deposit.

Twentymile Creek. Twentymile creek, a small stream about 7 miles in length, enters Quesnel river on the north side about 12 miles below Quesnel Forks. There the Quesnel Hydraulic Gold Mining and Development Company is continuing operations under the management of Mr. K. C. Laylander. During the visit of the writer, Mr. Laylander was absent supervising tests on the black sand concentrates, but the most cordial attention was received at the hands of Mr. Carver, bookkeeper of the company, and Mr. Hill, hydraulic foreman.

The deposits being worked on Twentymile creek consist of a 400-foot bank on the east side of the stream about 1 mile above its mouth (Figure 5, Section 6). The upper 90-foot stratum of this bank is of silt, sand, and gravel. This is underlain by a 70-foot bed of boulder clay composed mainly of small quartzite boulders firmly cemented in a

[1] For location of properties referred to in text, see Figures 2 and 4.

brown, clayey matrix. Below this lies a 240-foot bed of gravel of fluvioglacial origin. Volcanic bedrock, in places capped by a thin layer of yellow clay resulting from pre-

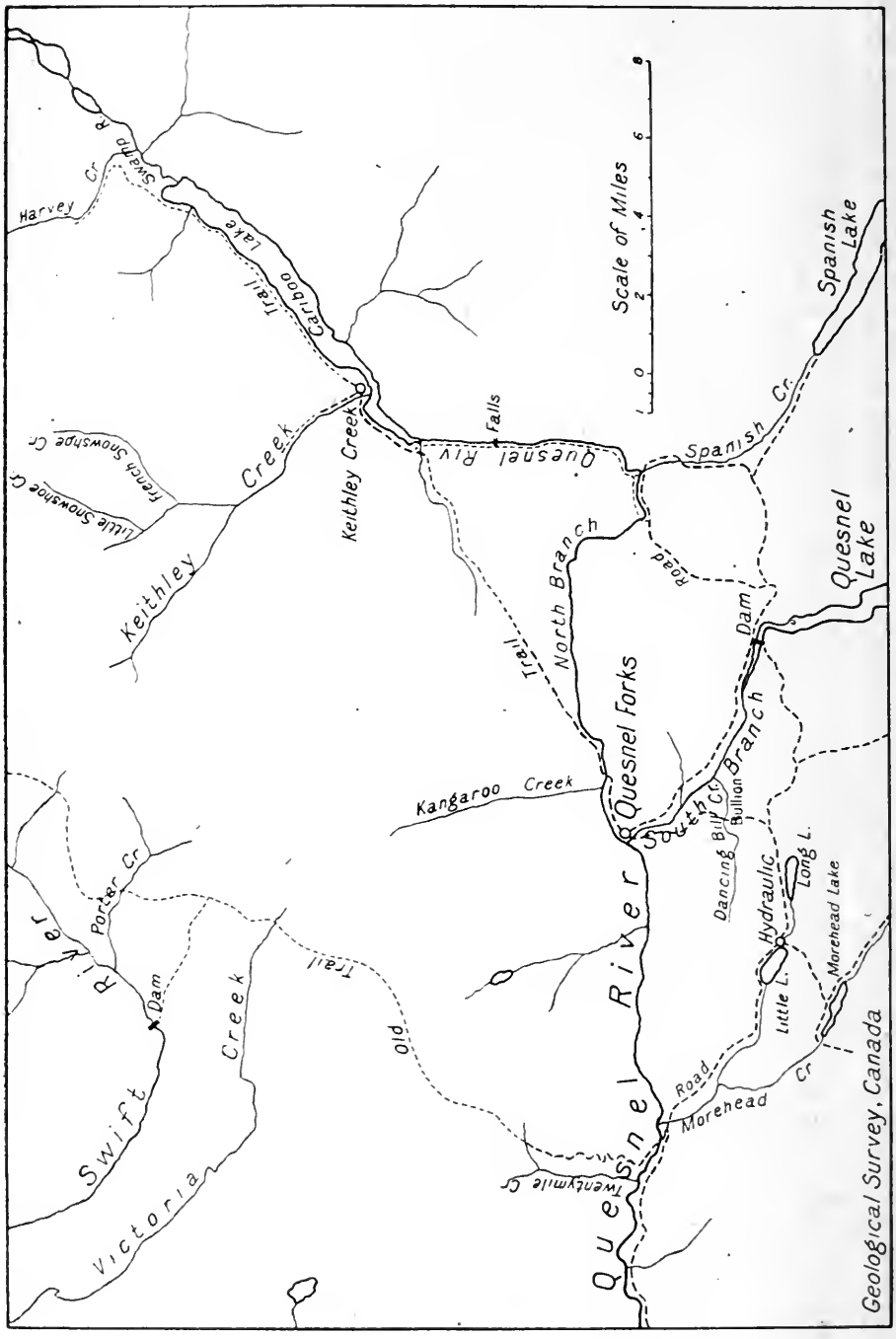


Figure 4. Quesnel River district, showing location of streams along which occur placer deposits referred to in text.

glacial decomposition of the rock, is to be seen outcropping in the pit, but as far as observed by the writer there were no indications suggesting a confined channel.

The values, which are mainly in fine gold, are said to occur disseminated through the bank, the main values, however, being concentrated in the lower part of the deposit.

The plant of the Quesnel Hydraulic Gold Mining and Developing Company is considered one of the most up-to-date hydraulic plants in the province of British Columbia. The plant, including its 19 miles of ditches, three large, inverted siphons, diverting dam on Swift river, and its many other unique features is so fully described in the annual report of the Minister of Mines, 1911, that it is unnecessary to give a description of it here.

An addition to the plant, however, has been made by Mr. Laylander in the installation of a mill for the saving of the black sand concentrates. An undercurrent placed in the lower part of the sluice boxes allows the concentrates to pass into a sump from which they are raised by means of an hydraulic elevator, a distance of 20 feet. From this they pass over a grizzly, the gravels passing through the grizzly being fed into two Neill jigs, and the remaining coarser gravels passing off to the dump. The concentrates from the jigs are then passed over a 15-foot by 4½-foot Overstrom concentrating table on which the sands are graded and the desired concentration obtained. In this way about 1,500 pounds of black sand concentrates are saved a day. As these concentrates are said to carry appreciable values in gold and platinum, this saving is quite a factor in the value of the deposit.

Keithley Creek. Keithley creek, a stream 10 miles in length, heads on Cariboo mountain and runs in a southeasterly direction into Cariboo lake. Along most of its course it occupies a narrow, V-shaped valley with banks of boulder clay and gravel rising steeply to a height of 200 to 300 feet. In places where the stream has cut through the drift and lowered its channel, either below the preglacial bed of the stream or into the rock shoulders which projected into the buried valley, the stream course is characterized by gorges and falls.

Remnants of at least two ancient channels buried beneath a blanket of glacial debris have been located and traced for great distances along the present course. The drift covering was not sufficient, however, to fill the valley completely and the stream in cutting out its present channel rarely lies more than 500 feet distant from the buried channels.

Of these preglacial channels one occurs about 120 feet above the stream, remnants of it being found on one side or the other of the valley. A later channel occurs near the level of the present stream bed, in some places being above the level of the stream and at other places below it. The gravels of this channel were found to be very rich and the stream where it has cut into or through them has been so enriched that certain parts have been worked six times.

At present the only mining carried on in this locality is a high channel deposit lying on the east side of the creek, 130 feet above the present bed of the stream and 1 mile above its mouth. Here is situated the Kitchener mine owned by Mr. R. W. Harrison and Mr. E. J. Worth. Mr. Harrison, assisted by three men, has driven a tunnel 100 feet through the outer rim rock and has struck a very rich deposit of gravel. Two years ago Messrs. Harrison and Worth worked another part of the same bench a short distance away, which yielded over $18,000 from 10,000 square feet of bedrock surface; but the bench, averaging 40 feet in width, on being traced was found to have been cut away by later erosion and a considerable sum was expended in locating its continuation.

The gold, which was largely coarse, was found to occur in two paystreaks—one, containing the coarser gold, occurred in gravel lying near bedrock and in some places the gold was found wedged in the crevices of the quartzite schist to a depth of 2 feet; the other, a paystreak carrying somewhat finer gold, was found to be on a layer of silt occurring several feet above bedrock. Exceptionally high values were found beneath some of the large boulders lying on bedrock. Where potholes occurred, values were found around their rims and in small channels leading from them, but the potholes themselves did not contain sufficient values to make it worth while cleaning them out.

There is little doubt that many other rich sections of these old channels still remain in this neighbourhood undiscovered, so concealed by glacial drift that they were either overlooked altogether or the prospect tunnels run to locate them were too high or too low. If a road was constructed connecting this section with Barkerville or Quesnel Forks, so that a Keystone drill could be brought in, some of these likely areas could be prospected. At present prospecting has to be carried on by the slow, expensive, and unsatisfactory method of shaft sinking. Not only is it impossible to get in drilling machinery to carry on systematic prospecting, but even where favourable indications are met with, great difficulty is encountered in interesting capital in a deposit that is so difficult of access.

Harpers Camp. At this place the International Dredging and Drainage Company, a Victoria syndicate, is operating on a flat of Horsefly river. The company holds three 250-foot mining claims and one dredging lease extending for one mile along the river. Part of this ground was worked a number of years ago by Mr. R. T. Ward, and is said to have yielded rich returns.

The deposit consists of preglacial bench gravels lying on the northeast side of the present channel and buried beneath the covering of boulder clay and recent stream gravels. The gold ranges in size from flour gold to nuggets the size of birdshot. The fine gold occurs disseminated through the preglacial gravel bed, but the coarser gold was generally found concentrated either on bedrock or on a false bedding of clay lying about 14 feet below the surface. Phenomenally high values are said to have been derived from beneath a large boulder occurring on bedrock.

Hydraulic elevators were used by Mr. Ward in mining these deposits and four of these elevators may be seen almost completely buried in the old pits.

The present company is operating a power scraper, which appears to be well suited to a deposit such as this, where the gravels to be worked are shallow, the floor is broad and with a gentle slope, and the bedrock is of soft shale.

The plant consists of a 45-horsepower yarding donkey engine with 10- by 12-inch cylinders and a 3-drum hoist which operates a Stanley scraper of 2 yards capacity. The scraper is 4 by 8 by 2 feet and is bottomless, the base being supplied with eight 18-inch octagon teeth 1¼ inches in diameter. The material excavated is held in place by the sides and back of the scraper. The scraper is said to work satisfactorily through a vertical distance of 100 feet. The gin poles, which guide the drag cables, are 30 feet in length and 16 inches in diameter and are generally placed about 600 feet from the engine and about 300 feet apart. Owing to the slight gradient of the stream it was necessary to elevate the sluice boxes about 10 feet to secure sufficient gradient for sluicing and dumpage room. The scraper is hauled up an incline and over a hopper feeding into the sluice box. The daily capacity of the plant is placed at 500 cubic yards per 8-hour day. With a haul of 250 feet or less, one cubic yard a minute can be handled, the scraper making the forward haul in 1¼ minutes and the return in three-quarters of a minute. A DeVille gold saving machine is used in connexion with an undercurrent in the sluice boxes, to save the fine gold.

Owing to the large amount of tailings it was necessary to handle before getting into virgin ground, the returns so far have not been as satisfactory as had been anticipated. It is the intention in the near future to undertake systematic prospecting of this buried bench by Keystone drill and it is reasonable to look for the discovery of rich deposits similar to that already worked by Mr. Ward.

Black Creek. Black creek is a southward-flowing tributary of Horsefly river, joining the latter about 14 miles east of Harpers Camp. It is a small stream about 4 miles in length. Throughout its course it occupies a V-shaped valley, and descends rapidly through a series of gravel stretches and rock gorges to the main valley of the Horsefly.

The present stream valley through the greater distance lies within the preglacial valley which during Pleistocene time was almost completely filled by sand, gravel

and boulder clay. The preglacial valley was narrow and characterized by interlocking rock spurs, indications of which may be seen in the rock shoulders outcropping from beneath the blanket of drift. The stream in cutting its channel through the drift was in places superimposed on these valley spurs and along these parts of the course it is characterized by deep, narrow canyons. Two such canyons occur within 900 feet of one another in the lower part of the valley.

Indications met with along the valley suggest that seldom, if anywhere, has the present stream valley been cut below the bed of the preglacial channel. Attempts made so far to reach the bottom of the buried channel have proved unsuccessful owing to the presence of underground water.

Considerable prospecting has been done along the lower part of this creek with favourable results, the coarse gold recovered being derived from the rock slopes of the buried channel.

During the season of 1918, the Western Mines Exploration Syndicate of Vancouver was engaged in drilling operations on the lower part of the valleys, with the object of tracing the channel and testing the gravels. It is expected that further testing will be carried on next year and if the results warrant an attempt will be made to work this deposit.

Sufficient water collects in the drainage basin of the stream to make hydraulic operations possible on a small scale. Several good dam sites occur about 1½ miles farther upstream where rock shoulders have been found projecting into the valley from the east bank. An excellent site for a dump for the disposal of tailings occurs below the lower gorge. Since the gold values are generally to be found concentrated on bedrock it will be necessary to do considerable quarrying to lower the bed of the gorge to that of the preglacial valley. The use of this artificial outlet will probably be more satisfactory than locating the mouth of the buried valley and following up the old channel to this point.

Other Deposits. In company with the late Mr. Howard W. DuBois, the consulting engineer under whose supervision the plant of the Quesnel Hydraulic Company was planned and constructed, a visit was made to the placer deposits and plants at Bullion, South Fork pit, Morehead creek, Quesnel River dam, Quesnel Forks, and Fountain creek. At present none of these deposits are being worked, but it is expected that once normal conditions are restored work on most of them will be resumed.

CONCLUSIONS.

Practically every foot of promising placer ground in the Barkerville area is staked, though, due to the present adverse conditions, no work is at present being done on the majority of the claims. Some of these areas are lying idle due to the high operating costs having compelled the plants on them to close down, though work will probably be resumed when normal conditions are restored and sufficient capital can be acquired. Due to the scarcity of water other claims cannot be worked until the water now being used in hydraulicking of neighbouring deposits is available. Still others are temporarily idle due to the attempts made to exploit the deposit having proved unsuccessful. Many others, however, are being held purely from a speculative standpoint, the holders making no effort whatever to work them, but depending on the development work done on neighbouring claims to prove them as to their value, when they will seek to dispose of them at a profit.

As in comparison with the other mining methods employed the great proportion of the yearly output of this field is derived from hydraulic mining and since practically all the water in the Barkerville area is already taken possession of and is being used, the possibility of an increase in this phase of placer mining is very slight and is confined largely to the less exploited areas in the vicinity of Cariboo lake and Horsefly river. Although the former locality is at present practically deserted, an improvement in transportation facilities into the area would stimulate further prospecting along

the creeks of this region and there is reasonable ground to expect discoveries similar to that recently made on Keithley creek, of other rich deposits, that have been overlooked by early miners.

There is, however, a possibility of an increase of the mining of the deep ground along numerous creeks, including Williams creek, Slough creek, Big Valley creek, Lightning creek, Willow river, Jack of Clubs creek, Snowshoe creek, and many others. Considerable careful and systematic prospecting by keystone drilling has already been undertaken along many of these creeks and satisfactory values have been shown to exist, but the excessive pressure of underground water has made the exploiting of the deposits by drift mining impossible as yet. However, with the improvement in pumping machinery, the operators familiar with the magnitude of the obstacle to be encountered are confident that they will finally master the situation.

Much of the ground is suitable for dredging. As yet the main drawback to the employment of dredges is the distance the deposits are from railways and the consequent excessive cost in installing plants. With the completion of the Pacific Great Eastern railway to Quesnel, this obstacle will be greatly reduced though not altogether removed.

If cheap power were available much of the now idle ground would in all likelihood be worked. The amount of power thus demanded for the running of dredges and of pumps employed in connexion with drift mining, and for hydraulic purposes, in addition to that which would be consumed by the present working properties using fuel for power, would be so large as to, in all probability, warrant the installation of an electric plant. Indeed this question has already been considered in connexion with the two falls on Swamp river, one fall a few miles below the outlet of Isaac lake having a drop of 75 feet and the other a short distance below the outlet of Sandy lake having a drop of 70 feet; from which good routes are obtainable for a transmission line to Barkerville and neighbouring areas. Mr. M. Bailey who has thoroughly examined these undeveloped water powers estimated that the minimum capacity would be in the neighborhood of 50,000 horsepower. Due, however, to the present adverse conditions, the scarcity of labour, the high cost of supplies, and the distance from the railway, operators are reluctant to enter into any new project requiring a heavy outlay of capital.

BRITANNIA MAP-AREA.

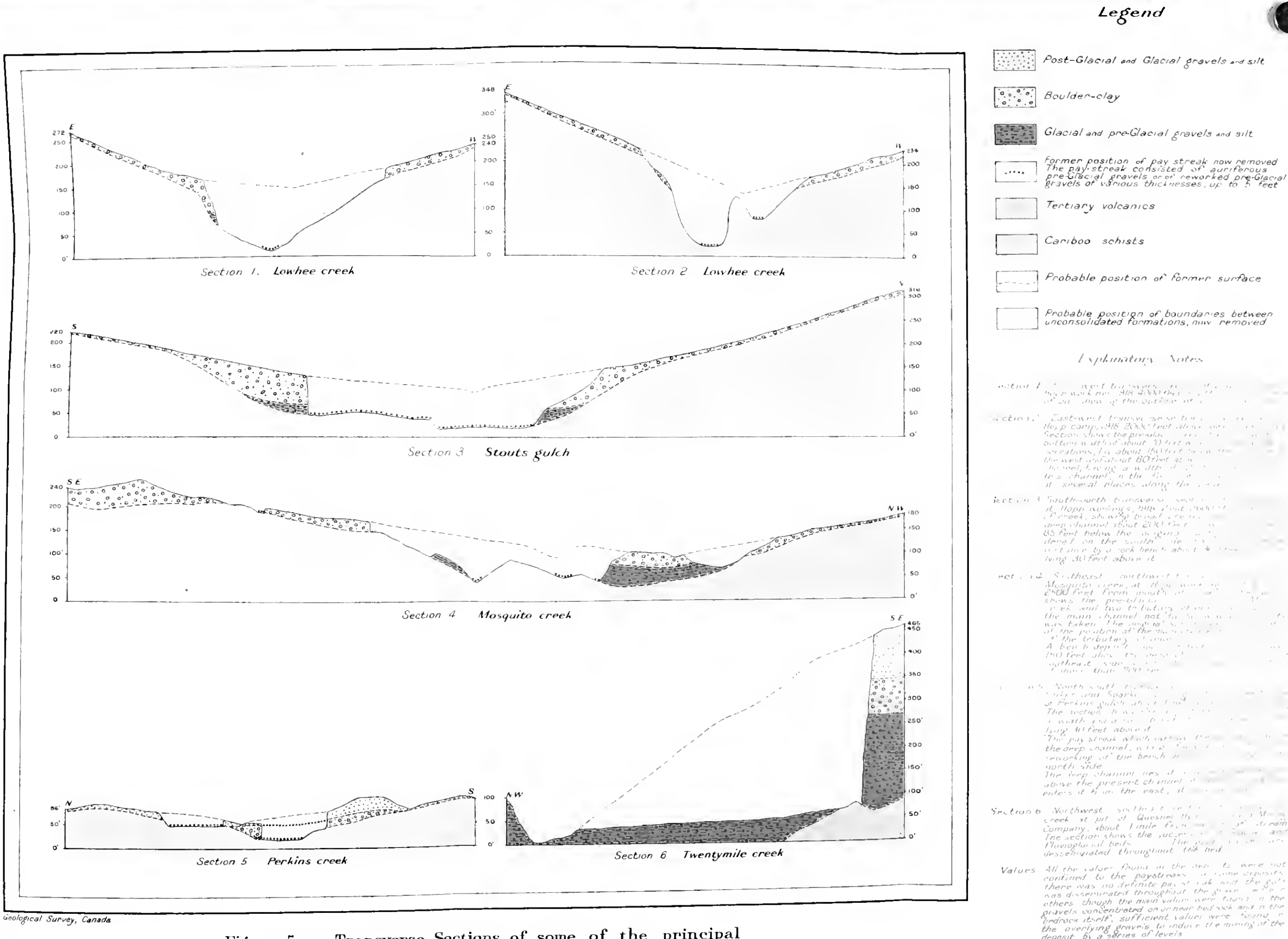
By S. J. Schofield.

A geological examination of the Britannia area was commenced in June and was carried on until August 1. Sufficient work was done to get a general idea of the rocks and structure of the area. The results obtained are in large part tentative, but as very little was known of the geology of the camp the following remarks may be of some value and interest.

The Britannia mining area is situated on the east side of Howe sound about 20 miles north of Vancouver. Britannia Beach is a regular call for steamers from Vancouver to Squamish.

GENERAL GEOLOGY.

The mineralized zone of the Britannia area is entirely located in a belt of metamorphosed sedimentary and igneous rocks which forms an inclusion in the granodiorite batholith of the Coast range. The trend of the rocks in this large inclusion, which has an approximate width of 2 miles and a length of 7 miles, is almost east and west with an average dip of 70 degrees to the south. Hence this mass has a trend which varies about 60 degrees from the general trend of the Coast range. Mr. Camsell also has noted the same phenomenon along the section of the Pacific Great Eastern railway from Squamish to Lillooet.



Geological Survey, Canada

Figure 5. Transverse Sections of some of the principal placer deposits of the Cariboo district, British Columbia.

To accompany Summary Report, Part B, by B R Mackay, 1918

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The geological horizons represented are as follows:

Era.	Period.	Lithological characters.
Quaternary.	Recent and Pleistocene.	Gravels and sands.
Tertiary.	——	Lamprophyre dykes.
Early Mesozoic.	Jurassic?	Aplite dykes. Coast Range batholith. Granodiorite.
	Triassic?	Quartz porphyry and diorite porphyrite. Britannia sills.
Palæozoic?	Devono-Carboniferous?	Britannia formation, argillites (slates), argillaceous quartzites, quartzites.

Britannia Formation.

This formation consists essentially of dark brown to black argillites (slates) which weather rusty brown. Interbedded with these argillites are bands of argillaceous quartzite and true quartzite. The age of these rocks is not definitely known, but LeRoy[1] considers them to be Palæozoic.

Britannia Sills.

The Britannia sills, which are about 1,800 feet thick, are tabular masses of igneous rock which conform in dip and strike with the enclosing slates. The composition of these masses ranges from a quartz porphyry to a diorite porphyrite. The quartz porphyry is a brownish grey rock in which crystals of quartz and orthoclase are embedded in the fine-grained groundmass. The diorite porphyrite is a dark green rock showing crystals of hornblende. The two varieties occur in the same sill. It has not been observed whether there is any definite arrangement of these varieties, but this problem is being studied. These sills are economically the most important members of the rocks exposed at Britannia, since the ore-bodies occur as impregnations in the quartz sericite schist which is a sheared porphyry.

Coast Range Batholith.

The Britannia sills and the Britannia formation, which may be considered as a unit since they were affected by the same geological processes, are surrounded, and underlain at some depth by granodiorite of the Coast Range batholith. This great batholith extends from the International Boundary line on the south in a north-northwesterly direction, to Alaska. The main mass holds many inclusions of all sizes which are termed roof-pendants or roof remnants and are more or less mineralized. Such an inclusion is the area of sedimentary and igneous rocks at Britannia. The rocks of this batholith vary in composition from a gabbro to a granite. In the neighbourhood of Britannia, the batholithic rock is a biotite granodiorite rather coarse in texture and of a greyish white colour. The contacts of the granodiorite with the slates and the porphyries are quite sharp and many blocks of these latter rocks are embedded in the granodiorite.

[1] LeRoy, O. E., "Preliminary report on a portion of the main coast of British Columbia and adjacent islands," Geol. Surv., Can., 1908, p. 15.

Aplite Dykes.

Aplite dykes which are associated with the granodiorite are not numerous and were seen only on the eastern ridge of Sky Pilot mountain. They are white in colour and are made up essentially of quartz and feldspar.

Diabase Dykes.

These dykes are narrow, having a width of from 2 to 8 feet. They are fine-grained and dark brown in colour. They consist of glassy feldspar in lath-like individuals with the interstices filled with pyroxene, the latter mineral being in small amount. The small, vug-like cavities which occur in this rock are filled or lined width bituminous material with a spherulitic structure. These dykes are very fresh and cut across the shear planes of the mineral zone. They may be associated with either the Tertiary or the Pleistocene volcanic field which occurs just to the north of Britannia

Quaternary Gravels and Sands.

The lower slopes of the mountains in the Britannia area are covered with a variable thickness of glacial drift. Numerous erratics were observed on the summits at an elevation of 5,000 feet. It might be mentioned here that the elevation of the glacial amphitheatres is as low as 4,000 feet. Recent gravels and sands are being deposited at the mouth of the streams.

BRITANNIA SHEAR ZONE.

Mineralization is confined to the great shear zone, sometimes called the Britannia mineral zone, which stretches at least from the Daisy mineral claim on Britannia creek to the Reggie claim on the west fork of Seymour creek, a distance of at least 5 miles. It is certain that the extent is greater than that given above, but the Reggie claim is as far east as the explorations were carried. The width of the shear zone varies greatly, but the maximum width would be about 500 feet. The shear zone strikes 140 degrees (astronomic) and dips from 40 to 70 degrees to the southwest. In the vicinity of the Empress claim the strike changes to 170 degrees (astronomic), but resumes the old strike on the Victoria and Queen claims. An examination of the bedrock geology shows that the Britannia formation and the Britannia sills make a similar change in strike. The shear zone is almost entirely located in the porphyry of the Britannia sills and as far as known to the Fairview sill, the sill in which the Fairview ore-body is located.

In the shear zone the quartz porphyry is changed to a fissile, greenish quartz mica schist, spotted with green films of chlorite up to an inch in length. This schist is locally called the Britannia schist. All gradations exist between the porphyry and the greenish quartz mica schist.

Mineralization.

Mineralization is confined to the shear zone at irregular intervals. The ore-bodies of the Jane and Fairview occur where the shear zone shows a decided change in strike. As this was the only area of mineralization examined it cannot as yet be stated that all mineralization of importance occurs at such points, but it is worthy of consideration and study. In the mineralized area the ore-bodies occur as lens-shaped masses separated by barren ground of various thicknesses. Mineralization is of the nature of impregnation and replacement of the schist by pyrite, chalcopyrite, and cupriferous pyrite, with minor amounts of zinc blende. The gangue is almost entirely the quartz schist which in places is highly silicified.

Gypsum and Sulphur.

The non-metallic minerals occurring in the schist belt are worthy of notice on account of their scientific interest and in the case of the gypsum of its future economic value.

The gypsum occurs in the quartz mica schists on the Fairview claim in lenses from 10 feet to 30 feet in width. It is greyish white in colour. The contact with the schist is quite sharp. Long, thin flakes of the schist are found in the gypsum and these flakes hold the original orientation of the schist. The gypsum shows no traces of shearing.

The sulphur occurs in the same shear zone, but widely removed from the locality of the gypsum. It occurs in well-defined veins and as impregnations in the schist. The veins vary in width from thin almost microscopic stringers to veins 4 inches wide. The sulphur is bright yellow in colour and when it impregnates the schists it gives them a yellowish green colour. The flakes of the schist close to the veinlets are separated by sulphur. Small, colourless crystals of gypsum were found associated with the sulphur.

Origin.

Since the sulphur and the gypsum are intimately associated in the shear zone, it is concluded that they are associated in origin. Gypsum in any large quantities has usually a sedimentary origin. At Britannia it is found in a shear zone in porphyry and since the gypsum is not sheared it must be of later age than the shear zone. This fact, that the gypsum is unsheared though it occurs in a strongly sheared zone, makes the theory impossible that it is a sedimentary remnant included in the porphyry. From the above facts it is concluded that the gypsum and the sulphur are of igneous origin. The large masses of gypsum as far as known do not show traces of sulphur and the veins of sulphur show only small crystals of gypsum; and since the sulphur and the gypsum are far apart, it is concluded that the sulphur was not derived from the gypsum. The relation of the sulphur and the gypsum to the ore-bodies is not known, except that they all occur in the same shear zone at various intervals. It is suggested that the sulphur and the gypsum are related to the magmatic reservoir which gave rise to the Garibaldi volcanic field which lies about 6 miles north of Britannia. Dykes of supposed Tertiary rocks cut the shear zone and these rocks are fresh and unaltered. Whether the ore deposits at Britannia are related to the same magma is not known, but it is generally held that the ore-bodies are connected with the intrusion of the Coast Range granodiorites of Jurassic age.[1] Further investigations will be pursued on this problem during the season of 1919.

Methods of Mining and Equipment.

A full description of the workings and the equipment of the Britannia mine is given by Mr. W. M. Brewer in the annual report of the Minister of Mines for British Columbia, page F271.

References to important researches of the geology are as follows:

LeRoy, O. E.—"Report on a portion of the main coast of British Columbia and adjacent islands", Geol. Surv., Can., Pub. No. 996, 1908.

McConnell, R. G.—"Britannia mine, Howe sound, B.C.," Geol. Surv., Can., Inter. Geol. Cong., 1913, Guide Book No. 8. Appendix.

Burwash, E. M. J.—"The geology of Vancouver and vicinity," University of Chicago Press, 1918.

[1] Schofield, S. J., Trans. Can. Min. Inst., 1918.

AINSWORTH MINING DISTRICT, B.C.

By S. J. Schofield.

Ainsworth mining district is situated on the west side of Kootenay lake about 25 miles from Nelson, B.C. Two months were spent in revising and obtaining additional geological data for the completion of a final report on the area.

GENERAL GEOLOGY.

The stratigraphy and lithology of the Ainsworth district may be expressed concisely in the following columns.

Quaternary.	Recent. Fluvioglacial deposits.	Calcareous tufa. Till, sands, and gravels.
	Unconformity.	
Jurassic.	Nelson batholith.	Lamprophyre dykes. Granodiorite, granite. Gneissic granite.
	Intrusive Contact.	
Carboniferous.	Skyline formation.	Argillite, fossiliferous limestone; thickness 4,000 + feet.
	Silver Hoard formation.	Limestone, argillites, schists; thickness 3,200 feet.
Carboniferous or pre-Carboniferous.	Josephine formation.	Hornblende schists, quartzites, and limestones; thickness 3,000 feet.
	Ainsworth formation.	Limestones; thickness 600 feet.
	Princess formation.	Garnetiferous mica schists, quartzites; thickness 1,250 feet.
	Early Bird formation.	Siliceous limestone; 2,300 feet.
	Point Woodbury formation.	Garnetiferous mica schists, quartzites; thickness 1,800 + feet.

General Statement.

The rocks at Ainsworth form a conformable succession of strata on a monocline dipping on an average 45 degrees west. This monocline when traced northwards passes into a syncline which may be correlated with the Millford syncline of the Slocan district. At Ainsworth the western limb of the syncline is replaced by Nelson granite. The formations pass gradually into each other so that definite boundaries are impossible to delineate.

Description of Formations.

Point Woodbury Formation. The rocks of this formation are well exposed along the shores of Woodbury point. The formation consists of a succession of thin-bedded quartzites and garnetiferous mica schist. These rocks are intruded by dykes of gneissic granite, in general parallel to the bedding planes but sometimes at a small angle to these planes.

Early Bird Formation. This formation is made up almost entirely of a dense blue, siliceous limestone in massive beds, separated by thin beds of garnetiferous mica schist. These rocks are well-exposed along the lake trail from Cedar creek to Woodbury creek, especially in the neighbourhood of the Early Bird mineral claim.

Princess Formation. The best exposure of these rocks occurs on the road from Ainsworth to a point one-eighth of a mile mile north of Cedar creek. The rocks are mainly garnetiferous mica schists and thin-bedded quartzites. The strata exhibit a great number of small folds and crenulations.

Ainsworth Formation. The Ainsworth formation consists essentially of greyish white, crystalline limestone weathering grey. Thin beds of mica schist are intercalated in the limestone. The Ainsworth limestone is well exposed along the shore from Coffee creek to Ainsworth. The lower tunnel of the Florence Silver mine is driven across the strike of this formation.

Josephine Formation. Josephine formation consists of a series of green hornblende schists, grey staurolite schists, and very thin-bedded, banded quartzites with narrow bands of crystalline limestone. These rocks are well exposed on the wagon road from the Spokane mineral claim to the United mineral claim, also in the neighbourhood of the Libby, Highland, and Josephine mineral claims. Economically this is an important formation as it contains the ore deposits of the Krao, Highland, and Florence Silver mines.

Silver Hoard Formation. This formation is composed of limestone, argillites, and staurolite schists. The limestone beds are of varying thicknesses and are composed of well-bedded, grey and white crystalline limestone often weathering white. The limestones are economically important as the No. 1, Star, Silver Hoard, and Gallagher ore deposits are associated with the limestones. A good section is exposed on the Ainsworth No. 1 road from the United to the No. 1 mineral claim.

Skyline Formation. This formation consists of argillites and well-bedded limestones and is exposed on the north fork of Woodbury creek between the third and fourth bridges on the creek. Fossils were found near the fourth bridge in the dark blue, thin-bedded limestones. E. M. Kindle, palæontologist to the Geological Survey, to whom the fossils were submitted, reports as follows: "The presence of the poorly preserved coral demonstrates a post-Cambrian age for the fauna. The general appearance of this coral, together with the dominance of crinoid stems in the fauna, leads me to consider the fauna as probably not later than Jurassic nor earlier than the Lower Carboniferous. As a provisional correlation it may be placed in the Upper Carboniferous."

Gneissic Granite. The gneissic granite is fine-grained, light-coloured rock composed of mica, quartz, and feldspar. It occurs in the rocks near the lake shore as sheets or dykes intruded parallel or almost parallel with the bedding planes of the sedimentary rocks. In contrast with the main Nelson batholith it has a distinct gneissic structure, is fine-grained, and non-porphyritic. Larger masses are exposed at the first bridge on Woodbury creek and south of the No. 1 mineral claim.

Nelson Batholith. The Nelson batholith is composed mainly of rocks of the granite family, with a distinct porphyritic structure; the phenocrysts being large crystals of a pink orthoclase. These granites are exposed just west of the Skyline mineral claim and occupy a great area west of Ainsworth.

Lamprophyre Dykes. These dykes are dark-coloured, showing very frequently large crystals of dark hornblende. The dyke which passes near the mouth of the lower Star tunnel is very coarsely crystalline and exhibits the large crystals of black glittering hornblende in a fine-grained, dark groundmass. It contains numerous pieces of foreign material, the most abundant being a grey, non-gneissic granite. Other dykes of the same family are to be seen in the Highland mine and one is exposed on the road just north of Cedar creek. These dykes are faulted by the fissures which form the veins in the Highland mine.

Fluvioglacial Deposits. The lower slopes of the Ainsworth area are partly covered by glacial material, especially on the Hardi and Star flats.

Calcareous Tufa. Calcareous tufa is being deposited by the hot springs at Ainsworth. It is a dark grey to brown, porous, calcareous tufa which contains numerous inclusions of the grasses and weeds growing around the streams which issue from the springs.

ECONOMIC GEOLOGY.

A description of the ore deposits in the Ainsworth area has been given in previous years.[1]

The results obtained during a re-examination of some of the properties substantiate the conclusions stated in the above reports. It can be stated that there are three favourable conditions for the formation of ore-bodies.

(1) In coarse, crystalline limestone near or at the upper contact of the limestone. Replacement deposits such as Florence, No. 1, Silver Hoard, Gallagher, Star, Krao.

(2) In fissure veins which have a displacement along the fissure at the contact of the banded quartzites with the overlying green hornblende schists. Highland, Florence.

(3) In the quartzites which show rolls or changes in dip. Formational veins such as Banker, Spokane, Trunket, Maestro.

LARDEAU MAP-AREA, B.C.

By M. F. Bancroft.

The general geology and mineral deposits of the Lardeau district were, in 1918, the subject of further investigation by the writer assisted by C. W. Robinson. The Lardeau district occupies a strip of territory extending northward from the head of Kootenay lake and lying between Arrow lake and Columbia river on the west, and the summit of the Pureell range on the east. During 1918, the field season was very short and it was possible to examine only about 70 square miles in the vicinity of Trout lake and Lardeau river.

The mining industry of the Lardeau district has contributed its quota of ore each year since 1896. The present scale of production is small, but represents only what is accomplished by about a hundred men, who are engaged in getting out a shipment or two of ore each season. The common type of workable ore deposits mined in the district is the fissure vein, mineralized with argentiferous galena, galena, tetrahedrite, zinc blende, chalcopyrite, stibnite, arsenopyrite, pyrrhotite, pyrite, bornite, molybdenite, gold, and native silver, the latter due to secondary enrichment in the veins. The vein fissures are closely associated with dykes and intrusions.

Considering the combined returns of mining for the Revelstoke, Trout lake, and Lardeau mining divisions, as representative of the Lardeau district, gold, silver, lead, and zinc, aggregating $65,257 in value, were mined in 1917. Five hundred and thirty-four tons of ore were shipped from thirteen mines, one property shipping over 100 tons. The quantity of ore shipped in 1916 was 521 tons. The recent output is considerably larger than that of the two preceding years, 1914 and 1915, when the tonnage was down to 149 and 155 respectively.

The grade of silver-lead ore that has been coming out of the Lardeau district is excellent. Owing to transportation difficulties only high grade ore can be shipped out at a profit. The silver-lead ores shipped from the Slocan mines are of very similar character: silver 90 ounces per ton, lead 40 per cent, and zinc 9·8 per cent, was the average of nearly 8,000 tons shipped from the Slocan district in 1905.

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[1] Schofield, S. J., Proc. Can. Min. Inst., 1915, p. 202.
Geol. Surv., Can., Sum. Rept., 1914, p. 38.
Geol. Surv., Can., Sum. Rept., 1915, p. 93.

This feature of high grade quality in the ore shipped from the three mining divisions is confirmed in the quantity ratios between the metals produced. The yield in silver and lead for the two year period of 1916 and 1917, for this district and that of Slocan, Slocan City, and Ainsworth mining divisions, is as follows:

Mining divisions.	Silver.	Lead.
Revelstoke, Trout lake, and Lardeau.. ..	60,152 ozs.	602,062 lbs.
Slocan and Slocan City.	3,028,147 "	26,223,664 "
Ainsworth mining..	545,663 "	14,237,219 "

The ratio in ounces of silver to pounds of lead for these three mining divisions, therefore, is 1:10, 1:8·6, and 1:26. The total production of silver and lead in 1914 to 1917, inclusive, from Revelstoke, Trout lake, and Lardeau mining division is 88,187 ounces silver, 820,015 pounds lead, a ratio of one ounce of silver to nine pounds of lead.

The cash value of the silver and lead produced during 1916 is $13,985 for silver and $12,760 for lead. The figures for 1917 are $29,187 silver and $31,270 lead. This 1917 record, where the value of the lead for the first time equals and even exceeds the value of the silver produced from this district is significant of war time dislocation of prices. The more common ratio of values between silver and lead from the Lardeau ores is given in the figures for 1915, which are $7,901 for silver and $3,713 for lead.

A new feature in the metal production for 1917 of Revelstoke, Trout lake, and Lardeau mining divisions is 33,279 pounds of zinc with a cash value of $2,518. Should the demand for zinc continue, some of the very good zinc properties of the Lardeau district could be opened up and zinc blende produced in paying quantities.

Silver-lead-zinc mining as carried on in the district to-day can scarcely be called a live industry, in view of the many prospects of long standing which continue idle, undeveloped, and therefore are as yet of uncertain value. This is particularly true of the properties in the southern Lardeau, which require wagon roads through the main valleys, up Duncan and Lardeau rivers, to encourage private enterprise. Unless prospecting is carried on more vigorously and new ore-bodies developed, mining in the Lardeau will make little progress, although the present scale of production can be maintained indefinitely.

Gold mining in Revelstoke, Trout lake, and Lardeau mining divisions, has to its credit from 1896 to 1917, inclusive, 19,737 ounces gold, of which 3,850 ounces is placer gold. Lode mining produced $1,282 and placer mining $1,000 worth of gold in 1917, a total of 112 ounces. During 1917 and 1918 one prospect on Silver Cup mountain in the Trout Lake mining division has shipped upwards of 20 tons of ore, giving 4·29 to 4·35 ounces of gold and 16 to 13 ounces in silver per ton. The future of gold mining in the Lardeau, especially in the central mineral belt from Camborne southeast to Gold hill, is not without promise.

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